DOCUMENT RESUME

ED 079 177 SO 005 838

TITLE	The River Basin Model: Computer Output. Water Pollution Control Research Series.
INSTITUTION	Envirometrics, Inc., Washington, D.C.; Environmental Protection Agency, Washington, D. C. Office of Research and Monitoring.
REPORT NO	R-16110-FRU-12-71-12
PUB DATE	Dec 71
NOTE	253p.
AVAILABLE FROM	Government Printing Office, Public Documents Department, Washington, D.C. 20402 (Order number EP1.16:16110FRU12/71-1; $1.00)
EDRS PRICE	MF-$0.65 HC-$9.87
DESCRIPTORS	Computer Graphics; *Computer Oriented Programs; Economic Factors; Electronic Data Processing; *Environmental Education; Government Role; Models; *Research Projects; Simulated Environment; *Simulation; Social Factors; *Water Pollution Control

ABSTRACT

This research report is part of the Water Pollution Control Research Series which describes the results and progress in the control and abatement of pollution in our nation's waters. The River Basin Model described is a computer-assisted decision-making tool in which a number of computer programs simulate major processes related to water use that take place within a geographical boundary. These processes include migration, housing selection, employment, transportation, shopping patterns, the allocation of leisure time, and water quality determination. Users of the model provide inputs to these programs on behalf of business activities in the economic sector, groups of people or population units in the social sector, and government departments in the government sector. This document includes printed computer outputs (maps showing characteristics of the region which differ geographically, summaries which present information in capsulated form, and detailed information from which the summaries are derived) which provide a yearly report of the status of the simulation and of interactions within the region during the previous year. (SHM)

CLEAN WATER

WATER POLLUTION CONTROL RESEARCH SERIES ● 16110 FRU 12/71-12

EPA

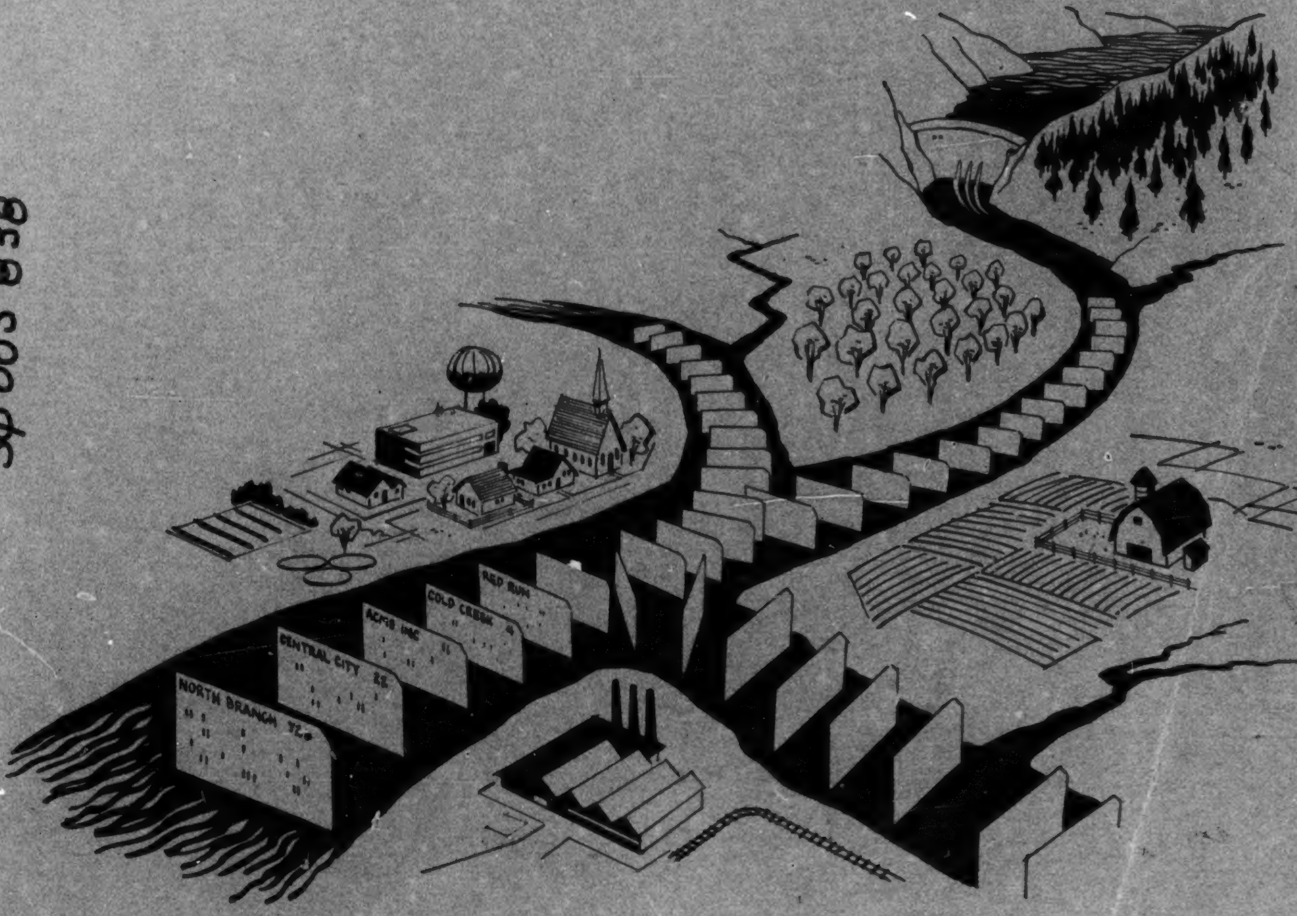
U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

ED 079177

The River Basin Model:

COMPUTER OUTPUT

SO 005 038


RED RUN
COLD CREEK
ACME INC
CENTRAL CITY SS.
NORTH BRANCH TR.

U.S. ENVIRONMENTAL PROTECTION AGENCY

WATER POLLUTION CONTROL RESEARCH SERIES

The Water Pollution Control Research Series describes the results and progress in the control and abatement of pollution in our Nation's waters. They provide a central source of information on the research, development, and demonstration activities in the water research program of the Environmental Protection Agency, through in-house research and grants and contracts with Federal, state, and local agencies, research institutions, and industrial organizations.

Inquiries pertaining to Water Pollution Control Research Reports should be directed to the Chief, Publications Branch (Water), Research Information Division, R&M, Environmental Protection Agency, Washington, D. C. 20460

ED 079177

The RIVER BASIN MODEL:

Computer Output

by

Envirometrics, Inc.
1100 17th Street, N.W.
Washington, D.C. 20036

for the
Office of Research and Monitoring
Environmental Protection Agency

Project #16110 FRU
Contract #14-12-959

December, 1971

EPA Review Notice

This report has been reviewed by the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names of commercial products constitute endorsement or recommendation for use.

COMPUTER OUTPUT MANUAL

I. Introduction to the Model 1

- A. Brief Description of the Model 1
- B. The Three Sectors 2
  - 1. The Economic Sector 4
  - 2. The Social Sector 5
  - 3. The Public Sector 6
- C. The Water Component 8
- D. The Local System 8
- E. The Unit of Time--A Round 10
- F. The Function of the Computer 11

II. Computer Printed Output Description 13

- A. Introduction 13
- B. Map Output 15
  - 1. Economic Status Map 18
  - 2. Government Status Map 21
  - 3. Socio-Economic Distribution Map 23
  - 4. Demographic Map 25
  - 5. Personal Goods Allocation Map 27
  - 6. Personal Services Allocation Map 29
  - 7. Business Commercial Map 31
  - 8. Utility Map 33
  - 9. Surface Water Map 35
  - 10. Municipal Treatment Plant Map.................. 37
  - 11. Municipal Inflow and Outflow Point Map......... 41
  - 12. Water Quality Map.............................. 43
  - 13. Water Usage Map................................ 47
  - 14. Municipal Services Map 49
  - 15. School Map..................................... 51
  - 16. Highway Map.................................... 53
  - 17. Planning and Zoning Map........................ 55
  - 18. Parkland Usage Map............................. 57
  - 19. Market Value Map............................... 60
  - 20. Assessed Value Map 62
  - 21. Farm Assessed and Market Value Map 64
  - 22. Farm Map 66
  - 23. Farm Runoff Map 68
  - 24. River Basin Flood Plain Map 70
  - 25. Topographical Restriction Map.................. 72
  - 26. Social Decision Maker Map 74
- C. Summary Information 76
  - 1. Demographic and Economic Statistics 76
  - 2. Summary Information for the Social Sector....... 80
  - 3. Summary Information for the Economic Sector..... 86

D. General Information 92

1. Migration Output (Explanation of Environmental Indexes)........................ 92
2. Water System Output 105
3. Employment Output 114
4. Commercial Output 125
5. Terminal Allocation Output 132

E. Social Sector Detailed Output 135

1. Dollar Value of Time 135
2. Social Decision-Maker Detailed Output........... 138
3. Social Decision-Maker Boycott Status Output 144

F. Economic Decision-Maker Detailed Output 146

1. Financial Summary.............................. 146
2. Loan Statement................................ 148
3. Land Summary.................................. 150
4. New Construction Table 150
5. Economic Boycott 153
6. Farm Output 153
7. Residence Detail 156
8. Basic Industry Detailed Output 164
9. Commercial Establishment Detail................ 173

G. Government Sector Detailed Output 181

1. Chairman Output 181
2. Assessment Department Output................... 185
3. Utility Department Output (Water Outputs) 187
4. School Department Output 201
5. Municipal Services Department Output 207
6. Planning and Zoning Department Output 213
7. Highway Department Output 215
8. Bus and Rail Company Output 220

Appendix A - Sequence of Computer Print-Out 229

I. INTRODUCTION TO THE MODEL

A. Brief Description of the Model

In a sense, the RIVER BASIN MODEL is a misnomer because if one places an emphasis on "River" it leads one to believe that the model is primarily concerned with water management. The emphasis should be placed on "River Basin", and that term should be interpreted in its broadest context as meaning a geographical area of land. Through its two major components -- human interaction and computer simulation -- the model represents the economic, social and governmental activity that takes place within the geographical boundaries defined by the river basin or more simply by a group of contiguous counties.

The model is unlike most other simulation or human interaction models. It was not designed to accomplish any one specific purpose. Rather it was designed to let its users represent the major economic, social, and governmental decision-makers who cause a regional system to function and change on a year-to-year basis. As part of the functioning of this regional system, water is demanded by industries and municipal water suppliers and pollution is generated by manufacturing and commercial activities, by people, and by farm activities.

The model is a computer-assisted decision-making tool, in which a number of computer programs simulate major processes that take place in the local system such as migration, housing selection, employment, transportation, shopping patterns, the allocation of leisure time, and water quality determination. Users of the model provide inputs to these programs on behalf of business activities in the economic sector, groups of people or population units in the social sector, and government departments in the government sector.

Normally, the users of the model are assigned decision-making responsibility for businesses, population units, and government departments in a gaming format. This means that users become members of teams that are assigned control of:

1. Economic Assets: cash, land, manufacturing plants, outside investments, commercial activities, and/or residences.
2. Social Assets: population units that are designated as high income, middle income, and/or low income.

3. Government Assets: power of the budget, taxing and assessing authority, service responsibility, and planning and regulatory power.

The computer print-outs for a year provide a detailed description of the regional area represented by the model, and the users of the model evaluate this status as individuals, as team members, and collectively to define problems, establish objectives, develop strategies, implement plans, and react to feedback from the new computer printout for the next year.

The initial starting position shows a particular set of allocations of the locals system's resources and their effects on the status of the local area. The users of the model evaluate their own particular status within the local system as well as the status of the area as a whole. They then interact with one another in a dynamic decision-making environment in which they collectively have control over the local water quality decisions that will be made, implemented, and reacted to. Some of the model players may have apparently only marginal interests in the local water quality issues because they are pre-occupied with running schools, building roads, earning incomes, producing manufactured goods, building housing, and supplying local goods and services. Others will have maybe more interest as they attempt to be elected into public office, run the planning department, collect taxes, recreate, and develop a generally pleasant environment for their new residential subdivisions. Still others might have a direct and pressing interest in the local water quantity and quality as they attempt to set and enforce water quality standards, supply municipal water, use surface water in their production process, and benefit from major water-based recreation areas.

In short, the entire local system is represented by the model and its users, and water decisions are placed within their realistic context of having different importance to different individuals as a function of their occupation, location, resources, and personal inclinations.

B. The Three Sectors

The model contains three basic decision-making sectors: economic, social and public. (Figure 1) Every city or region contains these three vital sectors whose interactions cause the area to function and to either grow and prosper or stagnate and decay. Decisions made by one group ultimately affect others

Figure 1

THREE DECISION-MAKING SECTORS AND CONSTITUENT TEAMS

ECONOMIC TEAMS
(Identified by single letter
codes: A, B, C, etc.)

INDUSTRIAL DECISION-MAKER

- HI-Heavy Industry
  - FL-Furniture and Lumber
  - SG-Stone Clay and Glass
  - MP-Primary Metals
  - MF-Fabricated Metals
  - NL-Nonelectric Machinery
  - EL-Electric Machinery
  - TE-Transportation Equipment
- LI-Light Industry
  - FO-Food
  - TA-Textiles and Apparel
  - PA-Paper
  - CR-Chemicals, Plastics and Rubber
- NS-National Service

COMMERCIAL DECISION-MAKER

- BG-Business Goods
- BS-Business Services
- PG-Personal Goods
- PS-Personal Services

RESIDENTIAL DECISION-MAKER

- RA-Single Family
- RB-Garden Apts. and Duplex
- RC-Multiple Unit and High Rise

GOVERNMENT TEAMS
(Identified by the specific
code preceding the department name)

CH-Chairman of Jurisdiction

CO-Councilman

AS-Assessment and Finance

SC-School

MS-Municipal Services

UT-Gas, Electric, Water and Sewer

HY-Highways

BUS-Bus Company

RAIL-Mass Transit Agency

PZ-Planning and Zoning

SOCIAL TEAMS
(Identified by double letter
codes: AA, BB, CC, etc.)

PH-High Income

PM-Middle Income

PL-Low Income

and one group often works against another group to achieve its goals. For example, proposed commercial developments by an economic group in a predominantly residential area can be blocked by residents of that area just as proposed changes by the government departments can be opposed by those participants in the economic or social sector.

1. The Economic Sector

Economic decision-makers are those businessmen who operate industrial, commercial, residential and farm establishments. Upon receiving output at the beginning of the round economic decision-makers review their economic status and make decisions for the present round. The various economic activities in the model have the following characteristics:

Basic Industry

Heavy Industry, Light Industry and National Services spend money for business goods and business services, utilities, a labor force, transportation, and taxes. In order to produce basic industry output which is then sold to the national markets at prices determined by national business conditions (the computer), owners of basic industries can make a wide variety of decisions. These decisions include purchasing land, changing salaries or maintenance levels, boycotting business goods and business services establishments, acquiring laons, building new businesses, upgrading existing businesses, demolishing old ones, and treating effluents that are dumped into the local water system.

The basic industry of the economy can be further subdivided into the following categories:

HI - Heavy Industry

  FL - Furniture and lumber
  SG - Stone, clay and glass
  MP - Primary metals
  MF - Fabricated metals
  NL - Non-electrical machinery
  EL - Electrical machinery
  TE - Transportation equipment

LI - Light Industry

  FO - Food
  TL - Textile, apparel and leather
  PA - Paper
  CR - Chemicals, plastics, and rubber

NS - National Services

Commercial Establishments

Business goods (BG) and business services (BS), personal goods (PG) and personal services (PS) spend money on many of the same items as basic industry in order to maintain a level of service capacity. This service capacity is consumed or partially consumed by local customers which include: the industrial sector, other commercial establishments and the population units (Pl's) who live in the city. Owners of the commercial establishments may make most of the decisions that owners of basic industries make in addition to setting prices for their products.

Residences

Single-family (RA), townhouse (RB), and high-rise (RC) residence units spend money on personal goods and personal services, utilities, and taxes, and earn income based on rent charged and the number and type of occupants residing in their housing units. Owners of residences may make the same types of decisions made by owners of basic industry in addition to setting the rent paid by their tenants.

Farms

Farm owners make very few decisions aside from how their land will be utilized and what level of fertilizer use they will employ.

2. The Social Sector

Decision-makers in the social sector represent the citizens who live and work in the simulated area. People are represented in terms of population units (Pl's). Each population unit represents fixed numbers of people (500). Population units are divided into three socio-economic groups: high income (PH), middle-income (PM) and low-income (PL). Because each class possesses its own expectations and behavioral patterns, each will have different preferences for residence, job, and schooling, etc. Social decision-makers can vote on behalf of the Pl's which they represent. Voting power is dependent upon the number of population units controlled, the number of registered voters in each, and their socio-economic class. Social decision-makers can also direct the population units under their control to boycott places of employment or shop locations. Social decision-makers can also allocate leisure time of their population units to be spent in any of four basic activities: extra work, adult education (public or private), politics, and recreation. The amount of time spent on each of these activities has an effect on the socio-economic status and/or the dissatisfaction index of people living within the city.

A significant part of the model centers around how P1's function within the local system during the course of each round of play which represents one year of time in the local area. Figure 2 shows the actions of P1's as they are affected by the major operating programs.

3. The Public Sector

In the model, the government sector deals with the problems of education, highways, municipal services, planning, zoning, utilities, water supply and quality and bus and rail transportation. The public sector is divided into two basic components. The first component includes elected officials: the Chairman and the Council. These officials are elected by the social decision-makers representing the people who live in each jurisdiction. The Chairman and Council set tax rates, approve budgets, grant subsidies and appropriations, and make appointments. Appointed officials named by the Chairman are heads of these six governmental departments: Assessment (AS), Schools (SC), Municipal Services (MS), Highway (HY), Planning and Zoning (PZ), and Utilities (UT). The Bus and Rapid Rail Companies are semi-private organizations which also may be appointed by the Chairman. Players representing these departments make decisions which include allocating capital and current funds, changing salaries and maintenance levels, requesting federal-state aid, changing district boundaries, constructing or demolishing public buildings, upgrading public buildings, changing levels of service, and transferring cash between accounts.

Figure 2

Example of How Population Units Are Affected by the Major Operating Programs of the Model

Major Operating Programs	Effect on Population Unit
Migration	Pl's move to the local system, find and change housing within the local system, leave the local system
Water System	Poor water quality incareses dissatisfaction and high coliform count increases health costs and time lost due to illness.
Depreciation	housing that depreciates becomes less attractive in the migration process.
Employment	Pl's are assigned to full and part time jobs that maximize net income (salary minus transportation costs), employers search for best educated workers.
Transportation	Pl's travel to work by the mode and route that minimizes total costs (dollar plus time), Pl's travel to shopping along the minimum cost routes.
School Allocation	Students of Pl's are assigned to public or private schools based upon the quality of public schools.
Park Allocation	Pl's are assigned to parks within a specified distance of where they live.
Time Allocation	Involuntary expenditures of leisure time are calculated as a function of the success of getting part time jobs, public adult education and the time spent on transportation.
Commercial Allocation	Pl's are assigned to stores at which the total costs are minimized (price plus transportation to the store).

C. The Water Component

The water component is a subsector that, in a sense, cuts across the other three sectors or is a part of each. For example, some of the industrial activities in the economic sector use surface water in their production process and all other economic businesses have some need for municipally supplied water. Population units in the social sector use water as a function of their income class and the type of housing they inhabit. In the government sector, the Utility Department is responsible for supplying the municipal water needs of the residents of its jurisdiction.

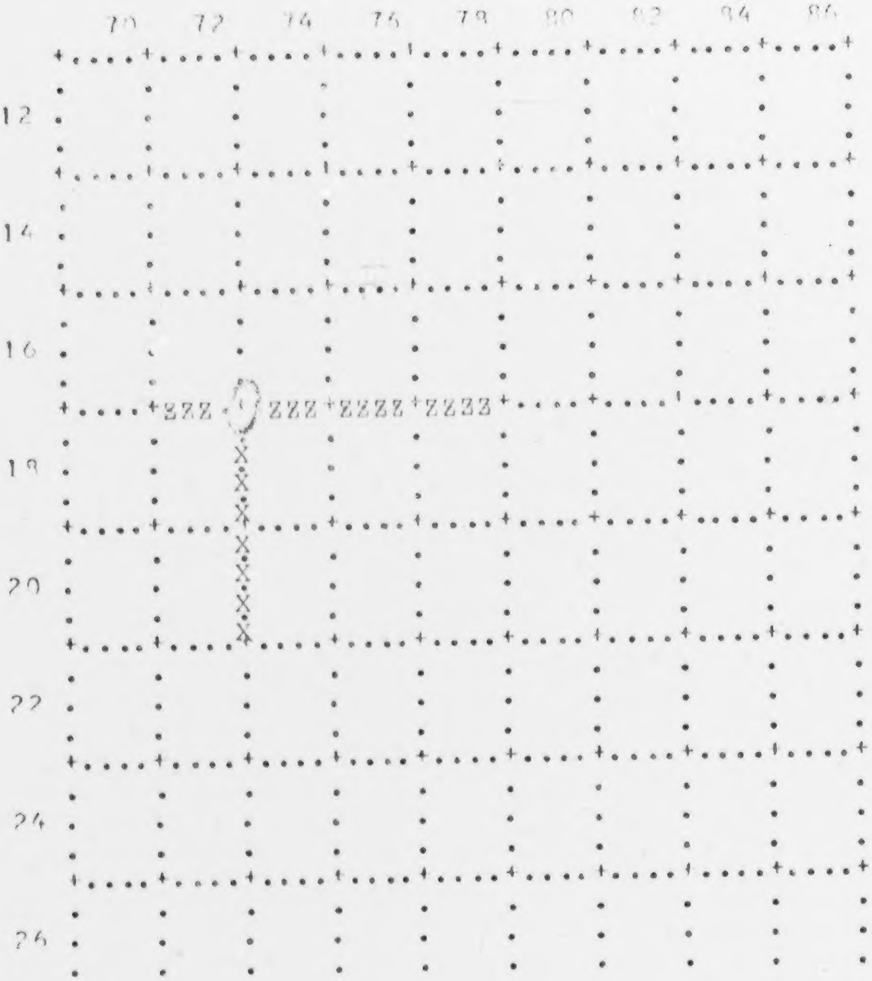
Each of the surface water users requires a specified quality of water and must either treat the water they intake or purchase water from a source outside of the local system. Every water user adds some pollutants to the water it returns to the water system. If left untreated, these water discharges may lower the quality of water of the body of water into which they are dumped. Since water users and polluters are located in a geographical space, acitivities upstream and downstream are affected differently by the dynamically created water quality conditions.

D. The Local System

The particular regional configuration being used is represented on a grid map consisting of 625 squares. Each square is of equal size and represents 6.25 square miles, 2.5 miles on a side. The grid and all of the computer maps are keyed to a coordinate system. Each parcel can be identified by its coordinates. Horizontal coordinates range from 70 to 118 and vertical coordinates from 12 to 60. Intersections are identified by the odd-numbered coordinates and highways are identified by even-odd (east-west) or odd-even (north-south) coordinates. In all cases, the horizontal coordinate (i.e., the larger number) is identified first.

For example, on the map in Figure 3 the shaded parcel is identified as 7014. Further, the four mile highway indicated by ZZZ is identified as 7217, 7417, 7617, 7817, while the two mile highway indicated by XXX is identified as 7318, 7320. The intersection marked by 0 is located at 7317.

Figure 3



E. The Unit of Time -- A Round

In the model, a round represents a year of change in the life of the simulated area. From the standpoint of the participants, however, a round may be thought of as a decision-making cycle which starts when they receive their computer output and ends when they hand in their decision input forms for processing by the computer.

During the early part of the typical round, decision-makers will be simultaneously reviewing their computer output and attempting to organize their possible actions. Economic decision-makers, for example, will probably attempt to acquire parcels of land that look good for future development purposes. They may attempt to secure loans from local or outside sources, apply for zoning changes, request utility expansions, and lobby for increased highway access. At the same time, social decision-makers might be bargaining for higher wages, requesting improvements in local schools and municipal services, lobby for higher water quality in the local river, and trying to promote those politicians who see things their way.

Meanwhile, the governmental decision-makers may be receiving requests from the economic and social decision-makers to lower taxes, improve schools, provide better municipal services, expand highways, build additional utilities, enlarge the park system, and improve other services. Budget officials are faced with the task of finding additional revenue to meet expanding public needs and dividing appropriations among the many local departments, all of which have attempted to justify their expanding budgets. Also the government office concerned with water quality might be pressuring the polluting industries to treat their wastes or face regulatory action. All water users might be concerned with water quality and quantity in so far as it affects their cost of using water and doing business.

Toward the middle of the round, it becomes clear to many decision-makers that all of their requests will not be granted. Thus, trade-offs and bargains must be made. Elected officials will begin to worry about staying in office. Departments must often plan to operate with less funds than they had requested. Low income representatives attempt to make their political power felt. High-income representatives attempt to maintain their status. Businessmen begin to look for short-cuts to reduce their losses and increase their activity and profit-making ventures. The water quality office begins to act upon its earlier threat.

As the round approaches a conclusion, the participants formalize the bargains they have made, continue to fill out their decision forms, terminate the negotiations on new wage levels, new prices and new rents, carry on their boycotts and complete any other possible actions. All water related decisions by the private and public decision-makers are completed. Treatment plants are built, industries shut down, fine levied, sampling stations constructed, etc.

When the round ends, participants campaign and carry out new elections, hold town meetings, debrief their actions, and develop new strategies while the computer performs its functions and prepares new output on the status of the simulated city.

F. The Function of the Computer

In the model, players are able to exercise a number of decision alternatives. Only some of these will be communicated to the computer, the rest will be part of the constant communication, bargaining and negotiating carried out in the game-room itself.

The computer performs several major functions in the model.

First, it stores all the relevant economic, social and governmental statistics for the area; updates data when changes are made; and prints out yearly reports on the status of the local system and reports for the economic, social, and government decision-makers.

Second, the computer simulates the actions of the outside system. For example, the computer simulates both a national business cycle, the probabilities of federal-state aid and interest rates on most loans.

Third, the computer performs certain routine functions or processes that would be time-consuming if the players themselves were to perform them. For example, the computer assigns workers from population units to jobs under the assumption that workers will attempt to earn as much money as possible. Other processes include assessing all property, assigning buyers of goods and services to shop at particular commercial establishments, assigning children to public or private schools based upon the capacity and quality of the public schools, and assigning population units to residences based on their desirability. The computer also simulates the migration process which moves population units into, out of, and within the local system. It also measures all of the types of pollution at all points along the river system and calculates a comprehensive water quality index.

II. COMPUTER PRINTED OUTPUT DESCRIPTION

A. Introduction

The printed computer output provides a yearly report of the status of the simulated region and of interactions within the region during the previous year. There are several types of output: maps showing characteristics of the region which differ geographically; summaries which present information in capsulated form; and detailed information from which the summaries are derived.

The figure on the next page shows the titles of the output sections in the order in which they are printed. That sequence follows neither the logical order of computer program operations nor the usual sequence in which a user examines the output. The code number beside the title of each section of output listed in this figure is the code number used in all examples of output included in this manual. The output is explained in this section in order of most general to most detailed information. Output is explained in the following order:

- maps
- summary information
- general information of relevance to all three sectors
- social sector detail
- economic sector detail
- government sector detail

There are a few standard features of all printed output sections. Each has a title which is a short description of the type of information given by the section of output. Each also contains both the round number and the game heading (the name of the data base being used or some other heading input by the director). Where relevant, a jurisdiction number is also printed.

After a few rounds' experience with the model, a model user usually needs only the printed computer output from a round and the Master Tables and input formats contained in this manual in order to play subsequent rounds.

RIVER BASIN MODEL OUTPUT

1. Migration
    - 1.1 Environmental Indexes
    - 1.2 Personal Indexes
    - 1.3 Dissatisfaction Cutoffs
    - 1.4 Migration Detail
    - 1.5 Migration Statistics
    - 1.6 Migration Summary
2. Water System
    - 2.1 Water User Effluent Content
    - 2.2 River Quality During Surface Water Process
    - 2.3 Water User Costs and Consumption
    - 2.4 Coliform and Pollution Index Values
3. Employment
    - 3.1 Employment Selection Information for PL Class
    - 3.2 Employment Selection Information for PM Class
    - 3.3 Employment Selection Information for PH Class
    - 3.4 Part-Time Work Allocation for PH Class
    - 3.5 Part-Time Work Allocation for PM Class
    - 3.6 Part-Time Work Allocation for PL Class
    - 3.7 Employment Summary
4. Commercial Allocation
    - 4.1 Personal Goods Allocation Summary
    - 4.2 Personal Services Allocation Summary
    - 4.3 Business Goods Allocation Summary
    - 4.4 Business Services Allocation Summary
    - 4.5 Government Contracts
    - 4.6 Terminal Demand and Supply Table
    - 4.7 Terminal Allocation Map
5. Social Sector
    - 5.1 Dollar Value of Time
    - 5.2 Social Decision-Maker Output
    - 5.3 Social Boycotts
6. Economic Sector
    - 6.1 Farm Output
    - 6.2 Residence Output
    - 6.3 Basic Industry Output
    - 6.4 Commercial Output
    - 6.5 Economic Boycott Status
    - 6.6 New Construction Table
    - 6.7 Land Summary
    - 6.8 Loan Statement
    - 6.9 Financial Summary
7. Social and Economic Summaries
    - 7.1 Number of Levels of Economic Activity Controlled by Teams
    - 7.2 Employment Centers
    - 7.3 Economic Control Summary for Teams
    - 7.4 Social Control Summary for Teams
    - 7.5 Social Control Summary Totals
    - 7.6 Economic Graphs for Teams
    - 7.7 Social Graphs for Teams
8. Government Detail
    - 8.1 Assessment Report
    - 8.2 Water Department Reports
    - 8.3 Sampling Station Report: Point Source Quality
    - 8.4 Sampling Station Report: Ambient Quality
    - 8.5 Utility Department Report
    - 8.6 Utility Department Finances
    - 8.7 Municipal Services Department Report
    - 8.8 Municipal Services Department Finances
    - 8.9 Municipal Services Department Construction Table
    - 8.10 Planning and Zoning Department Report
    - 8.11 School Department Report
    - 8.12 School Department Finances
    - 8.13 School Department Construction Table
    - 8.14 Highway Department Finances
    - 8.15 Highway Department Construction Table
    - 8.16 Rail Company Report
    - 8.17 Bus Company Report
    - 8.18 Chairman Department Finances
    - 8.19 Tax Summary
    - 8.20 Financial Summary
9. Summary Statistics
    - 9.1 Demographic and Economic Statistics
10. Maps
    - 10.1 Personal Goods Allocation Map
    - 10.2 Personal Services Allocation Map
    - 10.3 Business Commercial Allocation Map
    - 10.4 Municipal Service Map
    - 10.5 School Map
    - 10.6 Utility Map
    - 10.7 Water Usage Map
    - 10.8 Water Quality Map
    - 10.9 Municipal Treatment
    - 10.10 Municipal Intake and Outflow Point Map
    - 10.11 Surface Water Map
    - 10.12 Farm Runoff Map
    - 10.13 River Basin Flood Plain Map
    - 10.14 Farm Map
    - 10.15 Farm Assessed and Market Value Map
    - 10.16 Market Value Map
    - 10.17 Assessed Value Map
    - 10.18 Economic Status Map
    - 10.19 Highway Map
    - 10.20 Planning and Zoning Map
    - 10.21 Parkland Usage Map
    - 10.22 Socio-Economic Distribution Map
    - 10.23 Demographic Map
    - 10.24 Social Decision-Maker Map
    - 10.25 Topographical Restriction Map
    - 10.26 Government Status Map

B. Map Output

The model output includes several maps which visually represent characteristics of the simulated region which differ by location. The entire simulated region is represented on a single, two-page computer map. A map key is printed at the bottom of each page. Map symbols appear on a map in the three types of locations which can be specified in the model: parcels (squares), parcel edges (lines separating squares), and intersections of lines (parcel corners). Land uses and other characteristics of parcels are represented within the squares. Divisions between parcels such as roads or jurisdiction boundaries are represented between parcels, and activities such as terminals are represented at parcel corners.

The Map Titles and a brief description of their contents are given below, in the order in which they will be discussed. All information is located spatially.

Economic Status Map: economic owners, economic activities and operating levels, zoning, levels of utilities installed, amounts of undeveloped land, road types, terminal levels, jurisdiction boundaries.

Government Status Map: school levels, parks, municipal service levels, utility plant levels, road types, terminal levels, jurisdiction boundaries.

Socio-Economic Distribution Map: residence types and levels, number of Pl's of each class, road types, terminal levels, jurisdiction boundaries.

Demographic Map: populations, residential quality indexes, business value ratios, percent occupancy, road types, terminal levels, jurisdiction boundaries.

Personal Goods Allocation Map: PG shopping location for each class and residence, PG location.

Personal Services Allocation Map: PS shopping location for each class and residence, PS location.

Business Commercial Map: BG and BS shopping location for each business, BG and BS locations.

Utility Map: utility units served, utility units installed, utility plants, utility district boundaries, jurisdiction boundaries.

Surface Water Map: volumes of surface water, rates of flow, land area in water, directions of surface water flow, lakes.

Municipal Treatment Plant Map: municipal water intake treatment plants and levels, municipal sewage treatment plant types and levels, utility plant locations and code numbers, directions of surface water flow, utility district boundaries, lakes.

Municipal Inflow and Outflow Point Map: Municipal surface water intake points, municipal sewage outflow points, utility districts served by each, surface water qualities, directions of surface water flow, utility district boundaries, lakes.

Water Quality Map: economic activities and operating levels, surface water qualities, directions of surface water flow, lakes.

Economic Sector Water Usage Map: economic activities and operating levels, amounts of recycling, business effluent treatment types and levels, utility district boundaries, jurisdiction boundaries.

Municipal Services Map: economic activities and operating levels, municipal service units required, municipal services and their use indexes, municipal service district boundaries, jurisdiction boundaries.

School Map: numbers of public school students, numbers of private school students, schools and their use indexes, school district boundaries, jurisdiction boundaries.

Highway Map: economic activities and operating levels, road types, terminal levels.

Planning and Zoning Map: zoning, park, public institutional, land uses, road types, terminal levels, jurisdiction boundaries.

Parkland Usage Map: parks, populations served by park, park use indexes, road types, terminal levels, jurisdiction boundaries.

Market Value Map: market values of all non-farm land, privately owned buildings, and privately owned land and buildings, road types, terminal levels, jurisdiction boundaries.

Assessed Value Map: assessed values of non-farm privately owned land and buildings, road types, terminal levels, jurisdiction boundaries.

Farm Assessed and Market Value Map: assessed and market values of farms, amount of land in farms, road types, terminal levels, jurisdiction boundaries, lakes.

Farm Map: farm owners, amount of land in farms, farm types, levels of fertilization, road types, terminal levels, jurisdiction boundaries.

Farm Runoff Map: where runoff from farms flows, direction of surface water flow, lakes.

River Basin Flood Plain Map: river basins, dam priorities, flood susceptibility of each parcel, direction of surface water flow, lakes, jurisdiction boundaries.

Topographical Restriction Map: topographically undevelopable land, road types, terminal levels, jurisdiction boundaries.

Social Decision-Maker Map: social decision-maker controlling each class living on each residence parcel, road types, terminal levels, jurisdiction boundaries.

Economic Status Map

This map shows the economic sector owners of all privately-owned non-farm parcels and the economic activity, if any, on each parcel. A parcel can have only one economic owner and one economic activity. Owners of farm parcels are shown on the Farm Map. The types of economic activities represented in the model are listed in the Master Tables.

The economic owner of a parcel owns all of the land and developments on the parcel which do not belong to the government or which are not topographically undevelopable. If the economic owner sells land to another economic decision-maker, he must sell all of the privately-owned land and buildings on the parcel to the new owner. An economic decision-maker can sell any portion of undeveloped land on a parcel to a government department.

The Planning and Zoning Department may zone parcels. Zoning is a restriction on economic development. Once a parcel is assigned a particular zoning code, all new economic development on the parcel must conform to the new zoning. If a parcel is unzoned, there is no restriction on what type of activity may be constructed on it. The Economic Status Map key defines what private land uses are allowed under each zoning code.

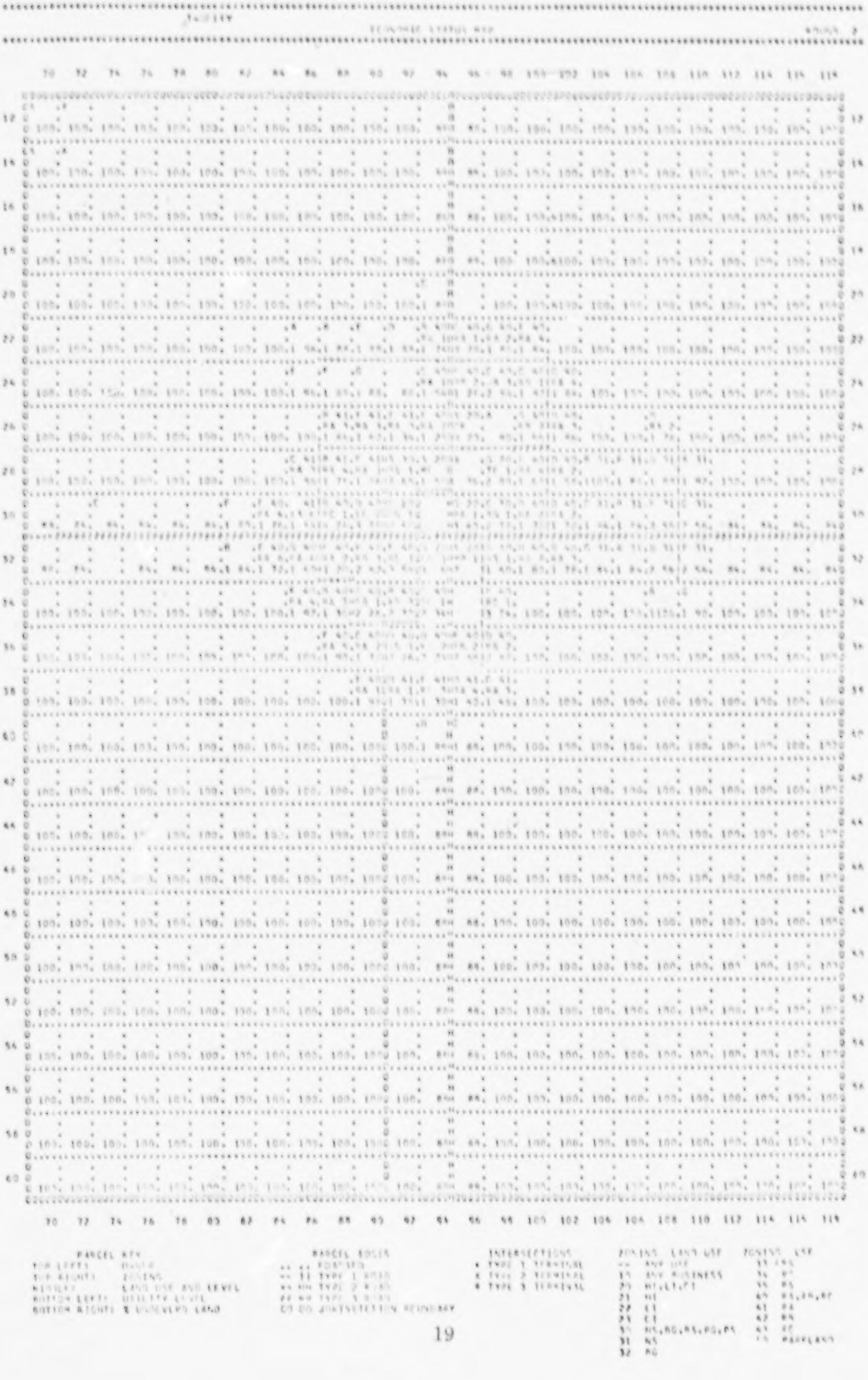
When a new economic development is constructed on a parcel, it must not only conform to the parcel's zoning; it must have sufficient utility service. Utilities are installed by the Utility Department in "levels" (1 - 9). Each level of economic activity requires a certain number of utility units, and each level of utility service supplies a fixed number of utility units to a parcel.

If an economic decision-maker has insufficient utility service for a proposed development, the Utility Department must install adequate utility service before the new development can be constructed.*

---

*There are two exceptions to the utility restriction on development: 1) RA housing can be built with "private utilities", which do not require utilities supplied by the Utility Department; 2) the director can override the utility restriction on individual developments.

Figure 10.18



Economic developments also require land. Each activity, depending on its type, requires a certain amount of land for each constructed level of development. Regardless of the operating level of an activity, the land consumed is that of the constructed level, which is always greater than or equal to the operating level. The amount of privately-owned land which is not in developments is classified on this map as undeveloped. If a parcel shows no undeveloped land, no further economic development can occur there unless the owner either acquires more land from a government department owning a portion of the parcel or demolishes existing economic developments. An economic decision-maker can acquire land by purchasing a parcel from another economic decision-maker or by bidding on land which is owned by the Outside.

The operating level of an economic activity is shown on the Economic Status Map. For most purposes, a business' operating level is the only level considered by the computer programs. However, a business pays property taxes and maintenance for its constructed level.

Government Status Map

Whereas there can be only one economic owner per parcel, any combination of government departments can own developed and undeveloped land on a parcel. The government departments which can own land, and the types of developments each can construct on a parcel are:

Department	Development Type
Utility Department	Utility Plant Water Intake Treatment Plant Sewage Outflow Treatment Plant: Chlorination Primary Treatment Secondary Treatment Tertiary Treatment
School Department	School Unit
Municipal Service Department	Municipal Service Unit
Planning and Zoning Department	Parkland Public Institutional Land
Highway Department	Road* Terminal*

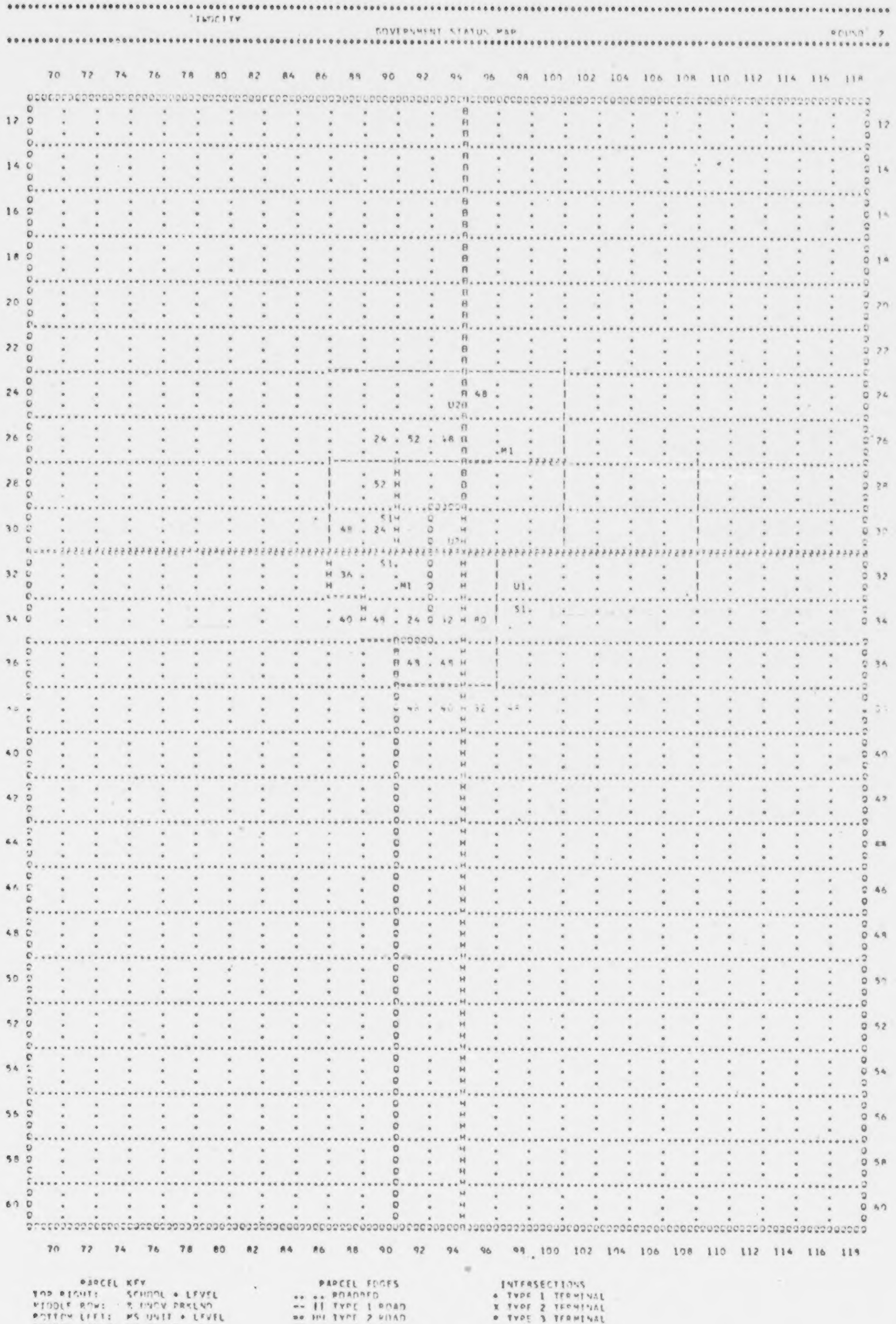
A government department can sell undeveloped land which it owns to either another government department or to the economic decision-maker owning the privately-owned portion of a parcel.

The government status map shows the locations of some of the types of government activities: schools, parks, utility plants, and municipal service units.

---

*A road requires land from the parcels on each side, and a terminal requires land from the four parcels touching the intersection at which it is located.

Figure 10.26


TWNCITY
GOVERNMENT STATUS MAP
ROUND 2
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
48
U28
24
52
48
M1
52
51
48
24
U28
36
51
M1
U1
51
40
48
24
32
80
48
48
48
40
32
48
PARCEL KEY
TOP RIGHT: SCHOOL + LEVEL
MIDDLE ROW: % UNEV PRKLND
BOTTOM LEFT: MS UNIT + LEVEL
BOTTOM RIGHT: UT PLANT + LVL
PARCEL EDGES
.. .. BOARDED
-- II TYPE 1 ROAD
== HH TYPE 2 ROAD
ZZ HH TYPE 3 ROAD
OO OO JURISDICTION BOUNDARY
INTERSECTIONS
+ TYPE 1 TERMINAL
X TYPE 2 TERMINAL
* TYPE 3 TERMINAL

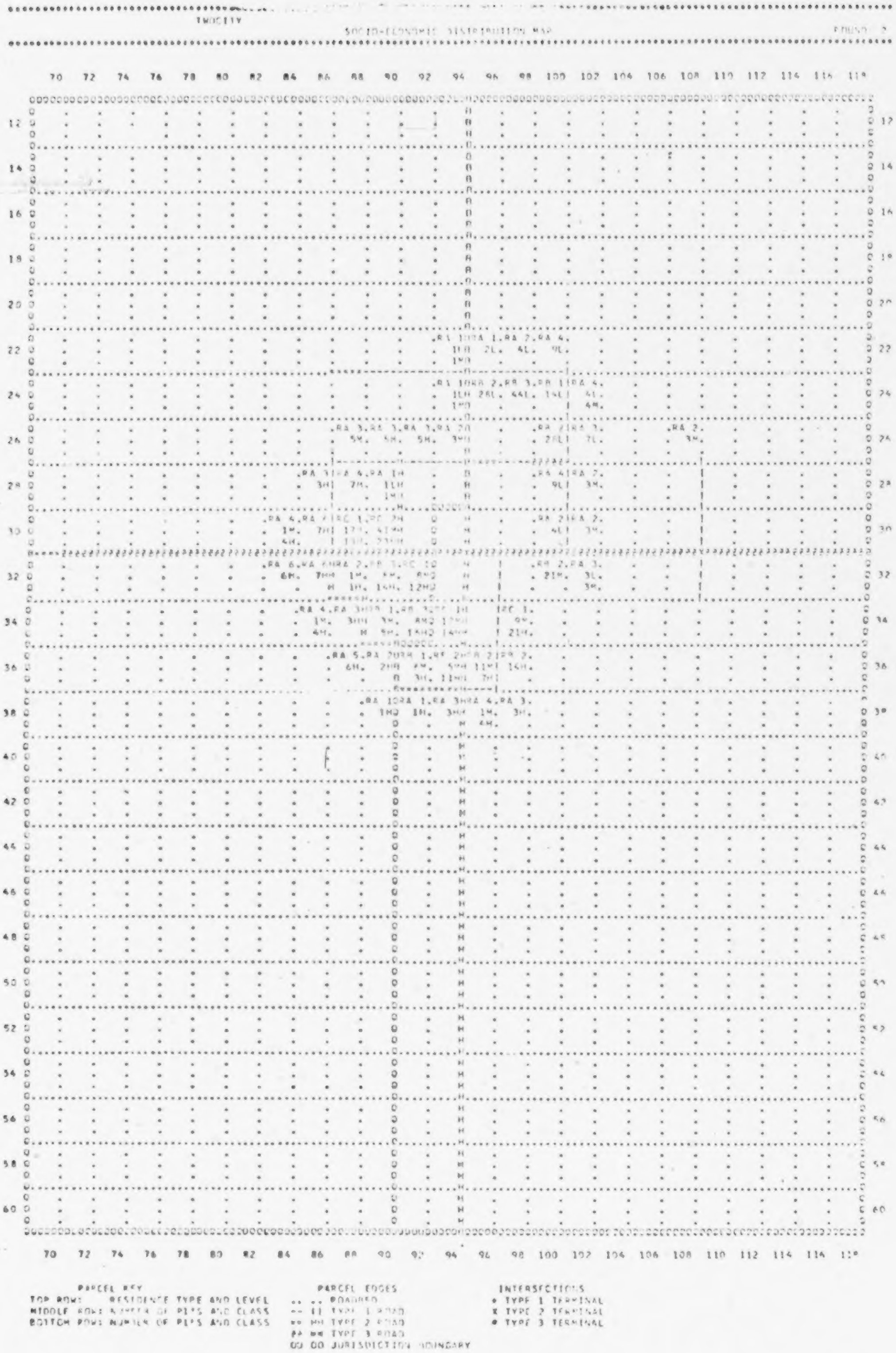
Socio-Economic Distribution Map

This map shows the number of Pl's of each class living on each residence parcel. The residence type and level are also printed.

The migration process allocates people to housing. Only two classes can live on a residence parcel simultaneously, due in part to the model's restriction that a PH will not move into a residence with a quality index below 71 and a PL will not move into housing with a quality index above 70. It is possible, if a residence depreciates below the minimum that a class will accept, that high-income, for example, will live in a residence with a quality index below 71 if the class was living on the parcel before the depreciation. In no case, however, can PH's reside on the same parcel with PL's.

Each level of a residence type provides a fixed number of space units. A Pl occupies a fixed number of space units, depending on its class. The percent occupancy of each residence is shown on the Demographic Map.

Figure 10.22


TWOCITY
SOCIO-ECONOMIC DISTRIBUTION MAP
ROUND 2
PARCEL KEY
TOP ROW: RESIDENCE TYPE AND LEVEL
MIDDLE ROW: NUMBER OF PI'S AND CLASS
BOTTOM ROW: NUMBER OF PI'S AND CLASS
PARCEL EDGES
.. .. ROADLESS
-- II TYPE 1 ROAD
== HH TYPE 2 ROAD
## TYPE 3 ROAD
OO OO JURISDICTION BOUNDARY
INTERSECTIONS
+ TYPE 1 TERMINAL
X TYPE 2 TERMINAL
* TYPE 3 TERMINAL

Demographic Map

The demographic map shows the number of people living on each residence parcel, the percent occupancy of each residence and the quality of all privately owned buildings and equivilent.

Overcrowding (over 100% occupancy) contributes to a residence's neighborhood index and to the health index.

The quality is expressed as the quality index for a residence and as the value ratio for non-residential activities. A value ratio is the ratio of the present condition of a business' buildings and equipment to their original condition, expressed as a percent.

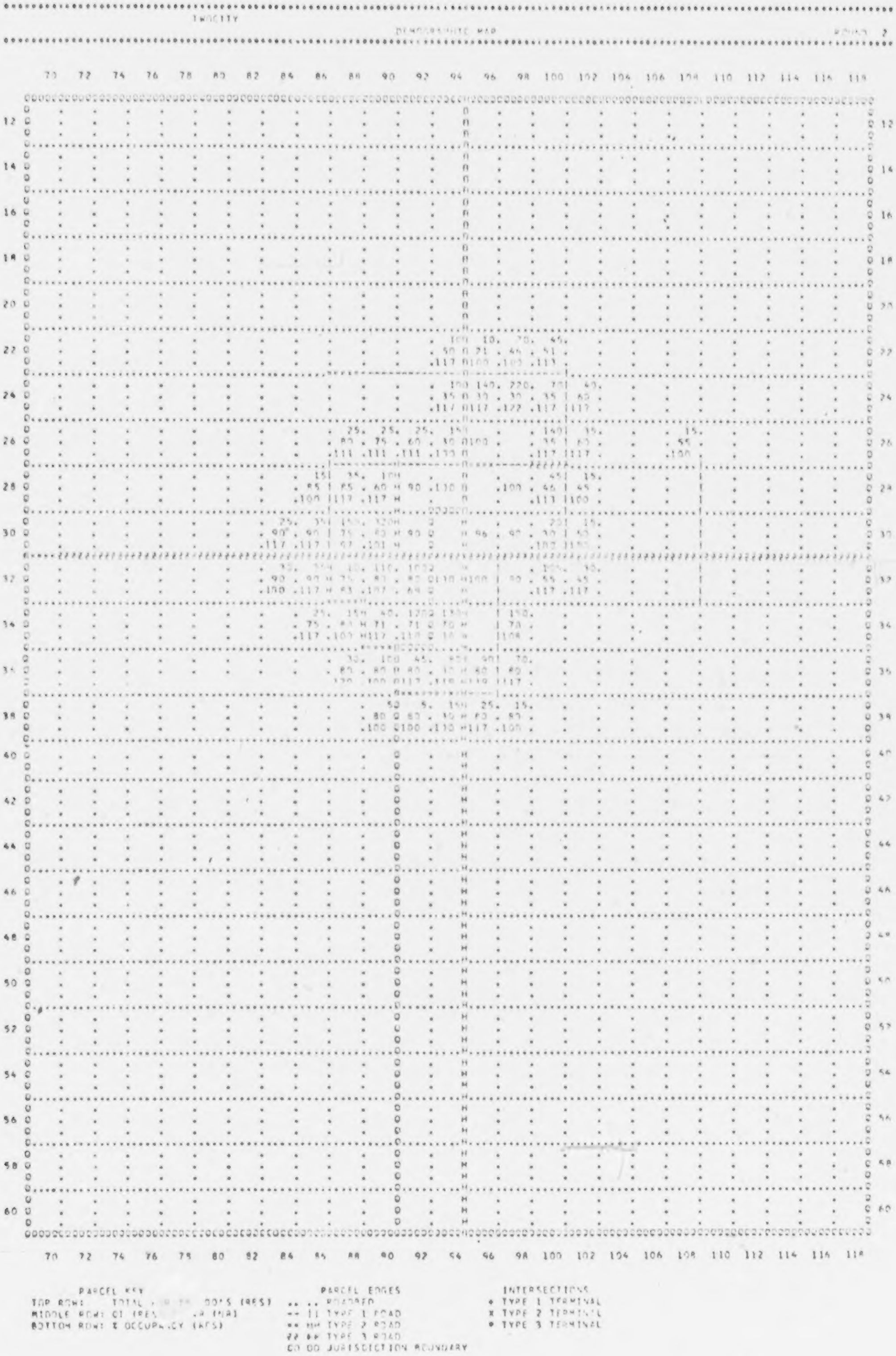
A quality index is somewhat different. Whereas a new business has a value ratio of 100, a new residence can have a quality index from 40 to 100.

Each year buildings and equipment depreciate in response to several conditions which vary by type of activity (see the Master Tables for the causes of depreciation). A business's depreciation is measured as a percent of original value (100). A residence's depreciation is measured as a percent of the original value of such a type of residence originally built at a quality index of 100, regardless of the original quality of the specific residence. Thus, business depreciation is a percent of original value but residential depreciation is a percent of quality index 100.

The owner of an activity can set a maintenance level for the activity. The maintenance level is the quality index or value ratio at which the owner will maintain the activity, regardless of how much it depreciates in a year. Not until the activity's value ratio or quality index falls to its maintenance level does the owner incur maintenance expenditures. The computer program depreciates and maintains buildings and equipment and charges the owner for the maintenance cost.

The Demographic Map shows quality indexes and value ratios after depreciation and after any maintenance.

Figure 10.23


TWOCITY
DEMOGRAPHIC MAP
ROUND 2
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
PARCEL KEY
TOP ROW: TOTAL [illegible] DU'S (RES)
MIDDLE ROW: CI (RES [illegible] (NA)
BOTTOM ROW: % OCCUPANCY (RES)
PARCEL EDGES
.. .. ROADBED
-- II TYPE 1 ROAD
** HH TYPE 2 ROAD
ZZ ## TYPE 3 ROAD
OO OO JURISDICTION BOUNDARY
INTERSECTIONS
+ TYPE 1 TERMINAL
X TYPE 2 TERMINAL
# TYPE 3 TERMINAL

Personal Goods Allocation Map

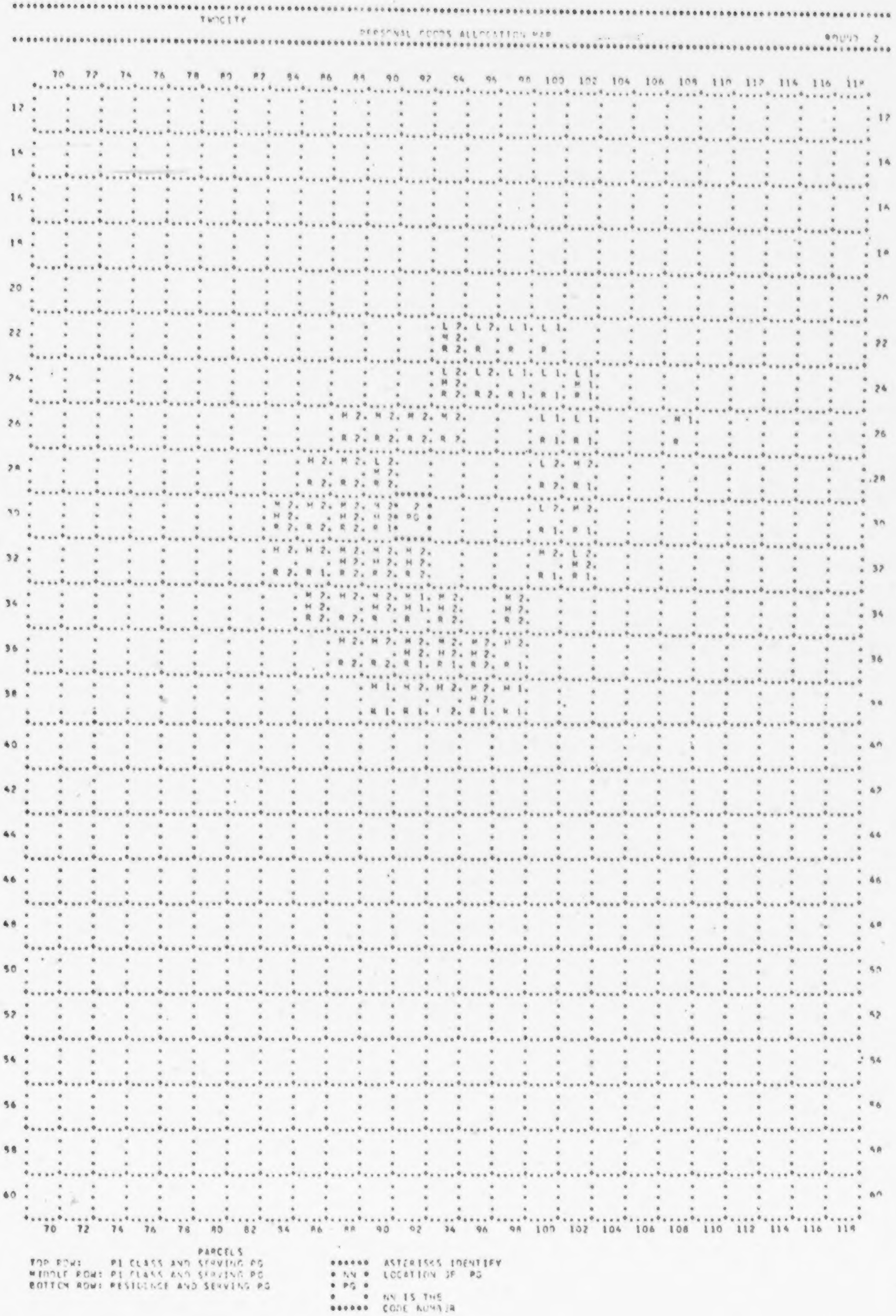
This map identifies the location of Personal Goods establishments and identifies the PG establishments that serve the customers from each parcel of land that has residences on it. PG establishments are located on those parcels that are encircled by asterisks. Their code number is also shown on the parcel where they are located.

It is possible to have up to three distinct customers on a parcel of residential land: population units from two classes and the residence landlord. No more than two classes of population may live on a single residential parcel. All population units purchase personal goods as part of their annual expenditures. All P1's of a class on a parcel purchase their personal goods at a single PG establishment. Landlords purchase personal goods only if they make maintenance expenditures. Buyers are assigned to specific commercial activities taking into account the price charged, transportation costs to the store, the capacity of the store, and boycotts.

The four letter codes used within a parcel on the map are: L = low income, M = middle income, H = high income, and R = residence. One or two of the first three codes prints if population units live on the parcel. If no one occupies the housing, no income class code is printed. The number after the letter code is the PG establishment code. The outside Local system PG suppliers are identified sequentially as determined by their location. Establishments located on parcels as one reads the map from top to bottom and from left to right have the lowest code numbers. The identification number assigned to a particular PG establishment might change from round to round if new PG's are being constructed at locations that are scanned prior to the parcel on which that particular PG is located.

The buyer code "R" will print on every parcel that has a residence. If the landlord makes maintenance expenditures then the R is followed by a PG establishment code. No code after the R indicates that no maintenance is being performed on that residence parcel.

Figure 10.1


TWOCITY
PERSONAL GOODS ALLOCATION MAP
ROUND 2
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
PARCELS
TOP ROW: P1 CLASS AND SERVING PG
MIDDLE ROW: P1 CLASS AND SERVING PG
BOTTOM ROW: RESIDENCE AND SERVING PG
ASTERISKS IDENTIFY
LOCATION OF PG
NN
PG
NN IS THE
CODE NUMBER

Personal Services Allocation Map

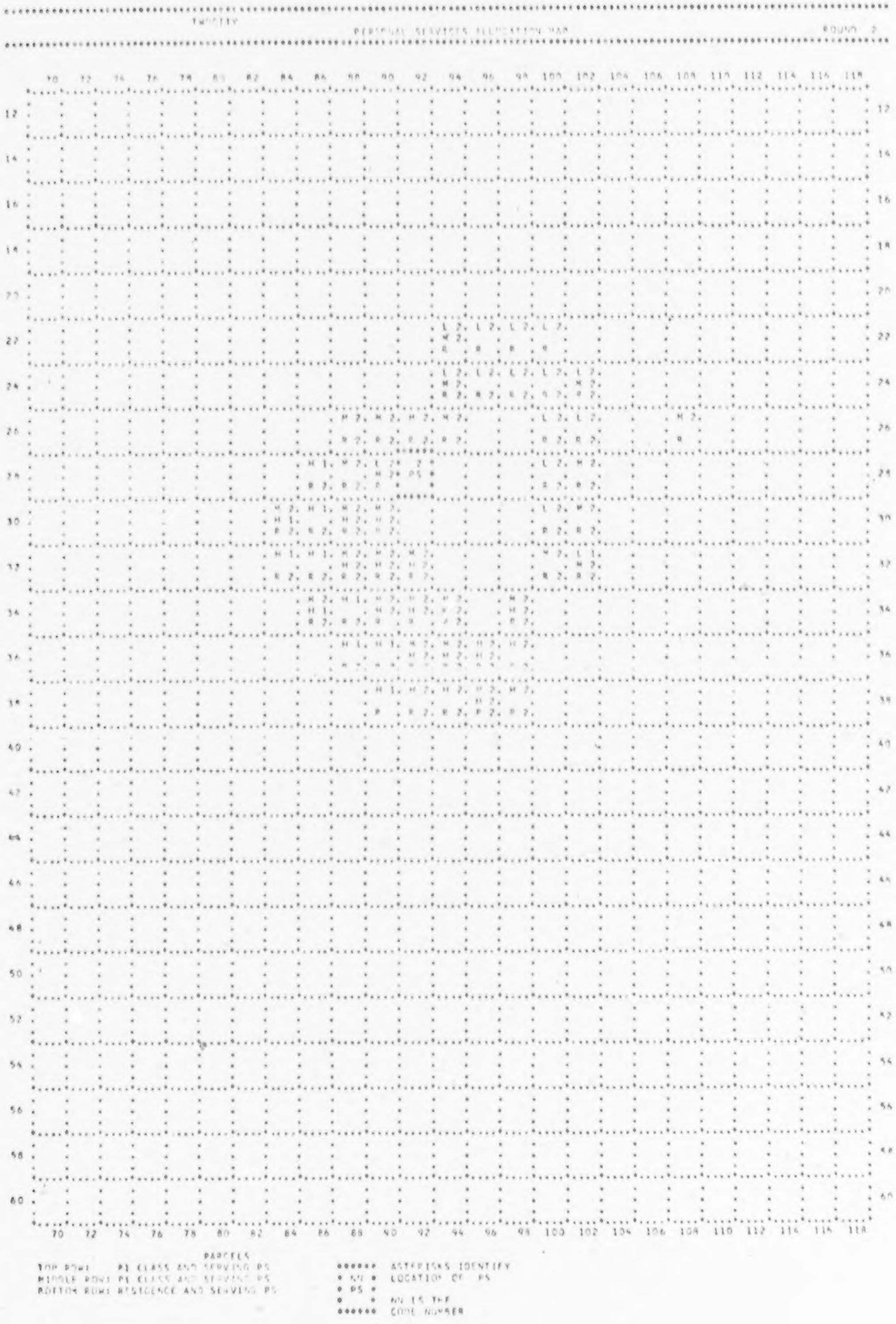
This map identifies the location of Personal Services establishments and PS establishment that serves the customers from each parcel of land that has residences on it. PS establishments are located on those parcels that are encircled by asterisks. Their code number is also shown on the parcel where they are located.

It is possible to have up to three distinct customers on a parcel of residential land: population units from two classes and the residence landlord. No more than two classes of population may live on a single residential parcel. All population units purchase personal services as part of their annual expenditures. All Pl's of a class on a parcel purchase their personal services at a single PS establishment. Landlords purchase personal services only if they make maintenance expenditures. Buyers are assigned to specific commercial activities taking into account price charged, transportation costs to the store, capacity of the store, and boycotts.

The four letter codes used within a parcel on the map are L = low income, M = middle income, H = high income, and R = residence. One or two of the first three codes prints if population units live on the parcel. If no one occupies the housing, no income class code is printed. The number after the letter code is the PS establishment code. The outside system suppliers are identified by the number code "1". Local system PS suppliers are identified sequentially as determined by their location. Establishments located on parcels as one reads the map from top to bottom and from left to right have the lowest code numbers. The identification number assigned to a particular PS establishment might change from round to round if new PS's are being constructed at locations that are scanned prior to the parcel on which that particular PS is located.

The buyer code "R" will print on every parcel that has a residence. If the landlord makes maintenance expenditures then the R is followed by a PS establishment code. No code after the R indicates that no maintenance is being performed on that residence parcel.

Figure 10.2


TWOCITY
PERSONAL SERVICES ALLOCATION MAP
ROUND 2
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
PARCELS
TOP ROW: PI CLASS AND SERVING PS
MIDDLE ROW: PI CLASS AND SERVING PS
BOTTOM ROW: RESIDENCE AND SERVING PS
ASTERISKS IDENTIFY
LOCATION OF PS
NN IS THE
CODE NUMBER

Business Commercial Map

This map identifies the location of BG and BS establishments and indicates the establishment code number for BG and BS establishments serving economic activities.

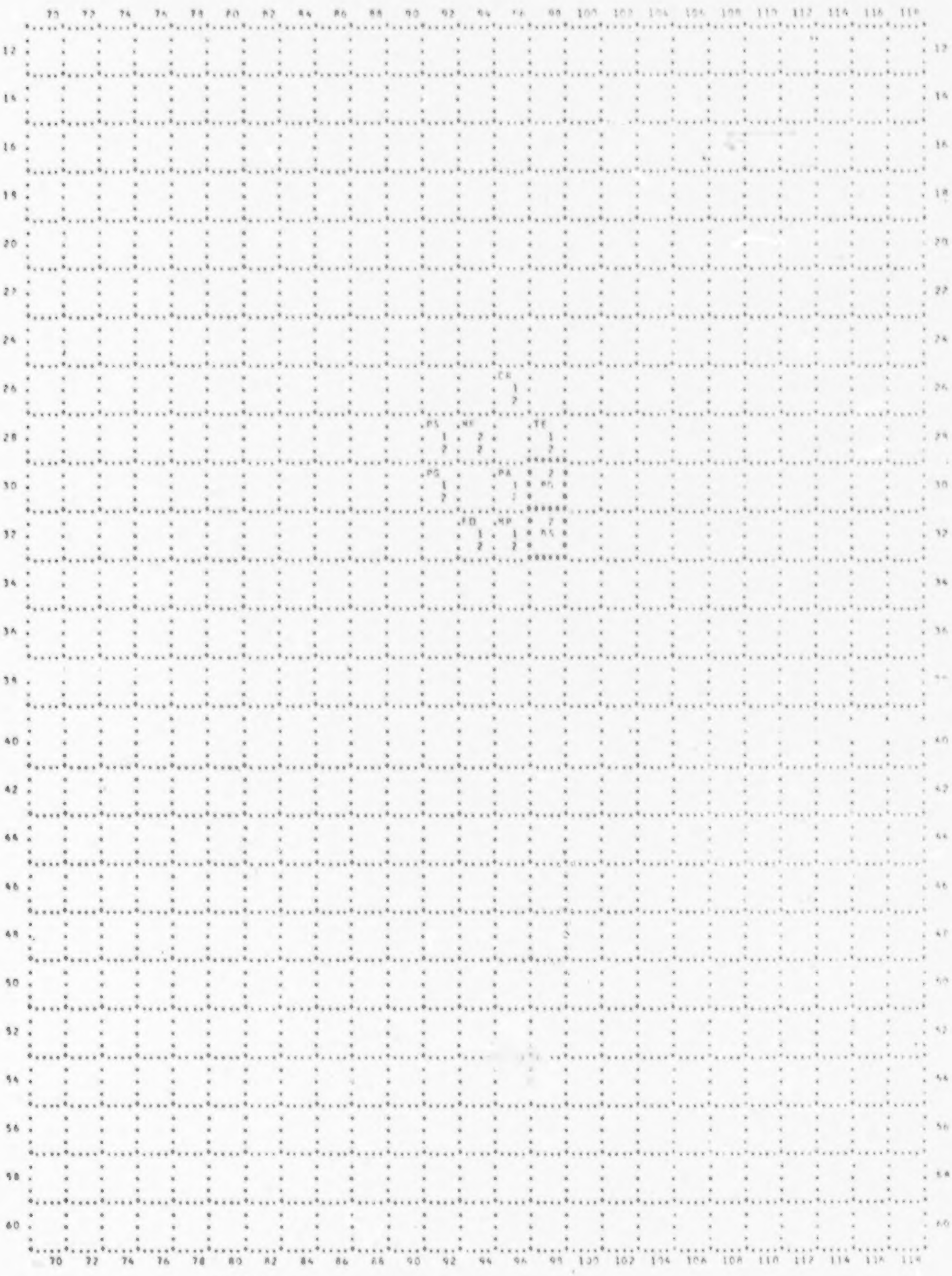
BG and BS establishments are located on those parcels that are encircled by asterisks and their identification number is shown. The outside system suppliers are always assigned the establishment code of "1". Local suppliers are then assigned numbers by starting at the top of the board and reading from left to right.

Local economic activities (industries and PG and PS commercial establishments) purchase BG and BS as part of their annual operation requirements. Buyers are assigned to a single specific supplier taking into account prices charged, transportation costs to the commercial establishments, capacity of the establishments, and boycotts.

The parcels on which buyers of BG and BS are located show the two letter code for the business activity and the number code of the BG establishment serving it (second line and the number code of the BS establishment serving it (third line).

TWOCITY

BUSINESS COMMERCIAL MAP ROUND 2



70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
CR 1 2
PS 1 2
MP 2 2
TE 1 2
PG 1 2
PA 1 2
2 BG
FO 1 2
MP 1 2
2 BS

PARCELS

TOP ROW: LAND USE
MIDDLE ROW: BG SERVING PARCEL
BOTTOM ROW: BS SERVING PARCEL

```
******  ASTERISKS IDENTIFY
* NN *  LOCATION OF BG OR BS
* BX *
*    *  NN IS THE
******  CODE NUMBER
```

Utility Map

This map designates the jurisdictional boundaries (000) and the district boundaries (xxx) for all utility plants within each jurisdiction. Utility districts are groups of contiguous parcels that are within the service area of a utility plant. There may be parcels of land that are not contained within a utility district.

The information contained on a land parcel shows the number of utility units required by utility users, the number of utility units installed on the parcel, and the number of the utility district serving the parcel.

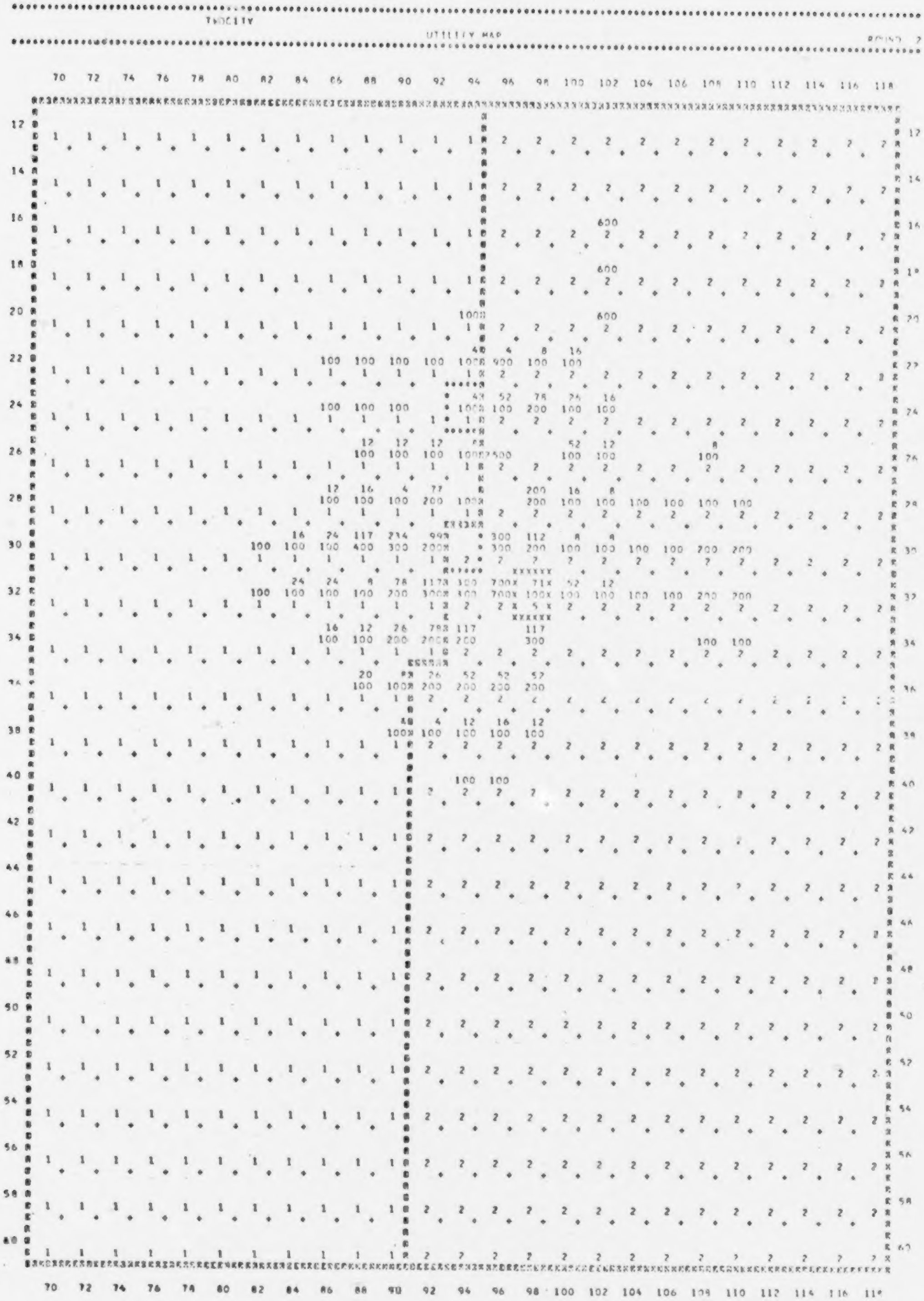
Utility plant locations are indicated on the Utility Map with asterisks surrounding the parcels on which the plants are located. Each utility district is identified with a unique utility number (starting with "1" and ending with "n", where "n" is the number of utility districts). The bottom piece of information on each parcel indicates the number of the utility plant serving that parcel.

The number of utility units consumed on a parcel is dependent upon the private land use activity. The map key shows the number of utility units demanded by a level one of each of the private land use activities.

The number of units installed on a parcel is a policy decision made by the Utility Department. The Utility Department provides one of nine levels of utility service to a parcel. Each level of utility service has a corresponding number of utility units that may be provided. Consult the Utility Master Table for the maximum number of utility units that may be provided for each level of utility service.

A parcel of land that is within a utility district may not be developed if the private development would require more units of utility service than could be provided by the present level of utility service provided to that parcel. Thus, the "UNITS INSTALLED" puts an upper limit on the "UNITS SERVED" for all parcels within utility districts.

Figure 10.6


TWOCITY
UTILITY MAP
ROUND 2
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60

PARCELS
TOP ROW: UNITS SERVED
MIDDLE ROW: UNITS INSTALLED
BOTTOM ROW: UTILITY CODE IF UT ON PARCEL

PARCEL EDGES
XX DISTRICT BOUNDARY
DD JURISDICTION BOUNDARY
BB BOTH
** UT ON PARCEL

UNITS REQUIRED		UNITS REQUIRED	
BASIC INDUSTRY		COMMERCIAL	
HI1	402	BC1	112
LI1	135	BS1	71
NS1	76	PC1	99
RESIDENCES		PS1	77
RA1	4	CONSTRUCTION	
RB1	26	CI1	NONE
RC1	117		

Surface Water Map

The Surface Water Map displays those characteristics of a surface water system which do not change dynamically during a particular run of the model. For each parcel on which there is surface water, the map shows the volume of water, its rate of flow, and the percent of the surface area of the parcel which is water.

The volume of water on a parcel is measured in millions of gallons per day (MGD) passing any one point on the parcel. The volume of water on a parcel affects both the water quality on a parcel and the amount of water which can be removed from the surface water on that parcel for municipal and industrial use.

The rate of flow of water on a parcel is measured in the number of parcels which water flowing at that rate would cross in one day. Water bodies undergo a natural cleansing process. The slower a river flows, the less distance some types of pollutants travel before they are naturally removed from the river.

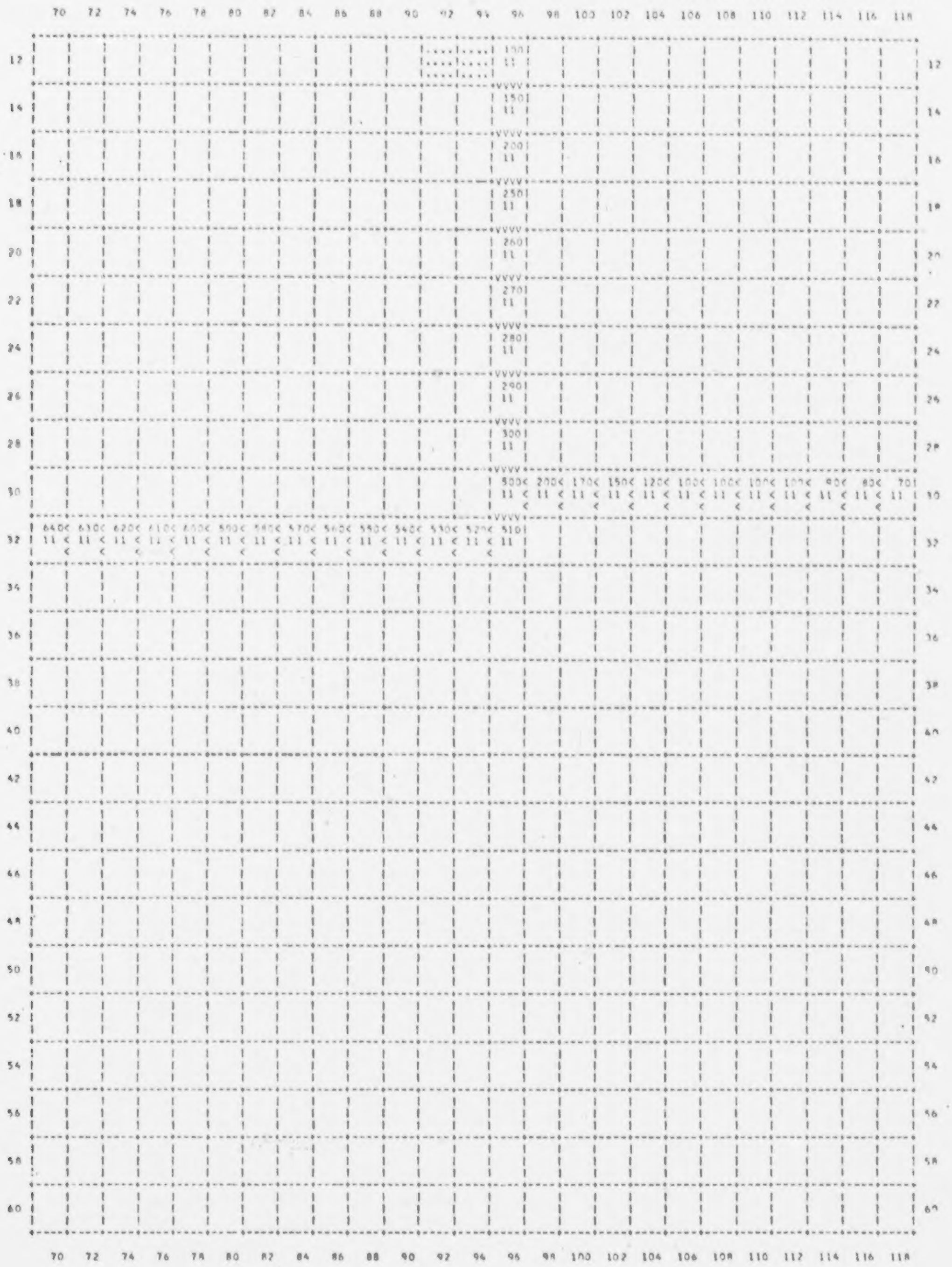
The amount of surface area occupied by water has one effect in the model: it preempts a portion of the parcel from use in other activities.

The map also displays the direction of the river's flow. The arrows between parcels point in the direction that the water flows. Water flows from parcel to parcel, traveling within parcels. If a parcel has a volume of water but no arrows pointing away from it, it either is the last parcel through which a river flows or has a self-contained surface water system which does not dynamically interact with the other surface water system parcels.

A parcel which is displayed as all dots is entirely water, usually a very large body of water into which a river flows, such as a large lake or ocean. The water on such a parcel does not interact with the surface water represented in the model; its quality is affected by activities in an area much greater than the simulated area. For convenience, such a water body is termed a lake in the model.

TWOCITY
SURFACE WATER MAP

ROUND 2


70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
100 11
VVVV
150 11
200 11
250 11
260 11
270 11
280 11
290 11
300 11
500< 200< 170< 150< 120< 100< 100< 100< 100< 90< 80< 70
11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11
640< 630< 620< 610< 600< 590< 580< 570< 560< 550< 540< 530< 520< 510
11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11 < 11

```
PARCELS
-------
   TOP ROW: AMOUNT OF SURFACE WATER
            ON PARCEL  (MGD)
MIDDLE ROW: RATE OF FLOW
BOTTOM ROW: PERCENT OF SURFACE AREA
            OF PARCEL IN WATER
....
....  LAKE PARCELS
....
```

```
PARCEL EDGES
------------
>AV<  DIRECTION OF FLOW
----  NO WATER FLOWING
      BETWEEN PARCELS
```

Municipal Treatment Plant Map

A Utility Department supplies water to all economic activities except some basic industries which obtain their own water from the surface water. Each utility district is also a water district. A parcel is supplied with municipal water and sewer service when utilities are installed on the parcel. The department can decide where to intake water, where to dump sewage, how much intake water it will provide, how much sewage treatment it will provide, and where treatment facilities will be located.

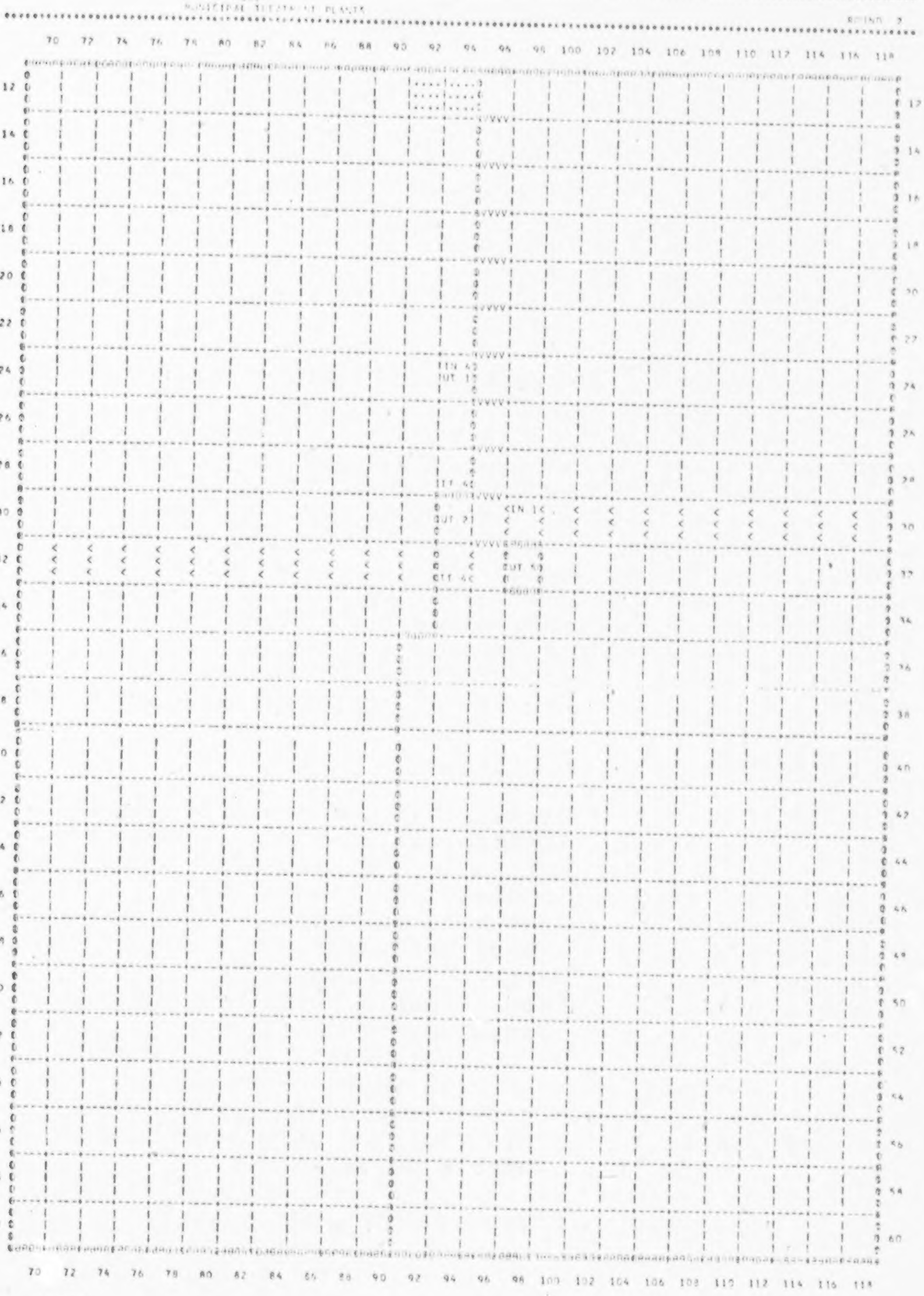
Municipal water intake and sewage treatment plants are located in the utility districts which they serve. An intake treatment plant processes the surface water removed from the parcel on which its intake point is located (not necessarily within the water district which it serves). All water treated by an intake treatment plant is processed to drinking water quality. The quality of the water before it is treated varies with the amount of pollution in the surface water where the intake point is located. There are nine water quality ratings, 1 being the best quality and 9 being the worst. A parcel's water quality rating is based on the volume of water on the parcel and the amount of pollution entering it from adjoining parcels.

Water Quality Rating	Description
1	Drinkable - best quality water
2	Drinkable - with minor treatment
3	Swimmable - direct body contact possible
4	Boating and Fishing - indirect body contact
5	Fair esthetic value
6	Poor esthetic value - treatable at moderate cost
7	No esthetic value - treatable at high cost
8	Negative esthetic value - treatable at very high cost
9	Unusable water

Seven types of pollutants are measured for the quality rating.

Pollutants	Description
BOD	Biochemical Oxygen Demand; the

Figure 10.9


TWOCITY
MUNICIPAL TREATMENT PLANTS
ROUND 2
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
IN 43
OUT 17
IN 1
OUT 21
OUT 50

PARCELS

TOP LEFT: IN FOR MUNICIPAL INTAKE
          TREATMENT PLANT
TOP RIGHT: LEVEL OF INTAKE TREATMENT PLANT
MIDDLE LEFT: UT FOR UTILITY DISTRICT PLANT
MIDDLE RIGHT: CODE NUMBER OF UTILITY DISTRICT
BOTTOM ROW: MUNICIPAL EFFLUENT TREATMENT TYPE AND LEVEL

....
.... LAKE PARCELS
....

PARCEL EDGES

><V^ DIRECTION OF FLOW

---- NO WATER FLOWING
     BETWEEN PARCELS

OOOO UTILITY DISTRICT BOUNDARY

Pollutants	Description
	natural breakdown of this pollutant causes a decrease in the concentration of dissolved oxygen in the water.
Chlorides	Chlorides are employed as an indicator of persistent pollutants.
Nutrients	Phosphate, nitrite, nitrate, nitrogen, and phosphorous.
Coliform Bacteria	Indication of the potential health hazard of a given body of water.
Temperature	A measure of the deviation from the normal temperature of the surface water.
Oil and Floating Solids	Any oil added to the system and all floating solids such as refuse, garbage, cans, boards, tires, etc.
High-Level Wastes	Highly toxic, non-degradable substances.

The quality of water at a district's intake point affects, among other things, the cost to process the water to drinking water quality. The water quality of a parcel is shown on the Water Quality Map. That quality is not affected by any pollution dumped on the parcel, only by pollution dumped on upstream parcels.

An inflow treatment plant, while able to make all but the worst (quality 9) water drinkable, has a capacity which is a function of its level. The amount of water which a district needs is a function of the needs of the activities located in the district, but the amount of water which a district can obtain may be limited by its inflow treatment plant capacity. Whenever a district cannot obtain all of its needed water for any reason, including insufficient inflow treatment plant capacity, the activities served by the district purchase that proportion of their water needs which cannot be met locally from the Outside at a high cost. The cost to construct an inflow treatment plant increases with the number of levels constructed. Unlike levels of other activities in the model, municipal treatment plant costs and capacities are not necessarily even multiples of level one costs and capacities. The land requirements, however, are multiples of level one.

Municipal sewage treatment plants can be constructed not only to different levels (capacities) but also to different types of treatment. The types of sewage treatment are, in increasing order of pollution removal:

Chlorination (CL)
Primary Treatment (PT)
Secondary Treatment (ST)
Tertiary Treatment (TT)

Tertiary treatment requires the three other types of treatment; secondary treatment requires chlorination and primary treatment. The level of treatment printed on the map is the level of the type printed and of all lesser types. There is no provision for the case of different levels of different types of treatment within a single district.

Since treatment plants have fixed capacities which vary by their levels, any district's sewage in excess of its plant's capacity flows untreated into the surface water on the parcel on which the district's outflow point is located.

Note that all of a district's intake treatment must be located on a single parcel. Likewise, all of its sewage treatment must be on a single parcel, although that parcel does not have to be the same one as that on which its intake treatment plant is located.

'UT' appears in the middle row of a parcel if there is a utility plant on the parcel. Next to the 'UT' is the code number of the utility plant. That number matches the number printed next to the district's intake and outflow points on the Municipal Inflow and Outflow Point Map.

Municipal Inflow and Outflow Point Map

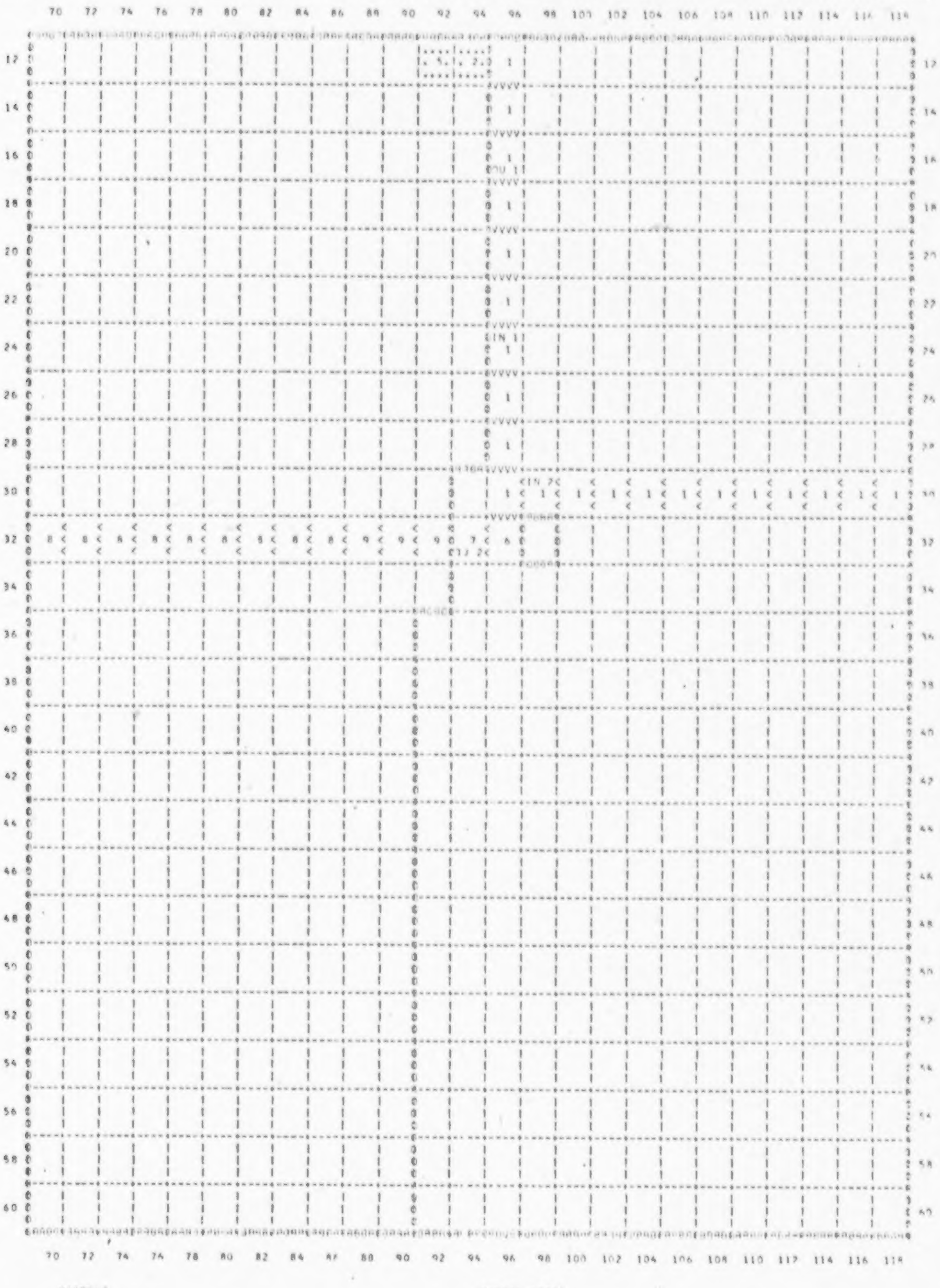
Unlike treatment plants, municipal intake and outflow points do not have to be located within the districts which they serve. This map shows where each district's intake and outflow points are located. The code number next to the 'IN' or 'OU' on the map is the code number of the utility plant in the district which the point serves.

Each district has one intake point and one outflow point. However, there can be more than one inflow and outflow point on a parcel. The map shows only one point, so if there is more than one on a parcel, only the Utility Department Report will note the existence of all of the others.

TWIN CITY

MUNICIPAL INFLOW AND OUTFLOW POINTS

ROUND 2


70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
OU 11
IN 11
IN 2
OU 2

PARCELS

TOP LEFT: IN FOR MUNICIPAL INFLOW POINT
TOP RIGHT: CODE NUMBER OF UTILITY DISTRICT INTAKING
MIDDLE ROW: SURFACE WATER QUALITY RATING
BOTTOM LEFT: OU FOR OUTFLOW POINT
BOTTOM RIGHT: CODE NUMBER OF UTILITY DISTRICT DISCHARGING

PARCEL EDGES

>AV< DIRECTION OF FLOW
---- NO WATER FLOWING BETWEEN PARCELS
0000 UTILITY DISTRICT BOUNDARY

.... LAKE PARCELS

Water Quality Map

The surface water quality on a parcel is a function of the pollution entering the parcel from adjoining parcels and of the amount of water on the parcel itself. The water quality on a parcel is not affected by any dumping activity on the parcel itself. Any activity which removes water from a parcel removes it at the quality shown on the Water Quality Map.

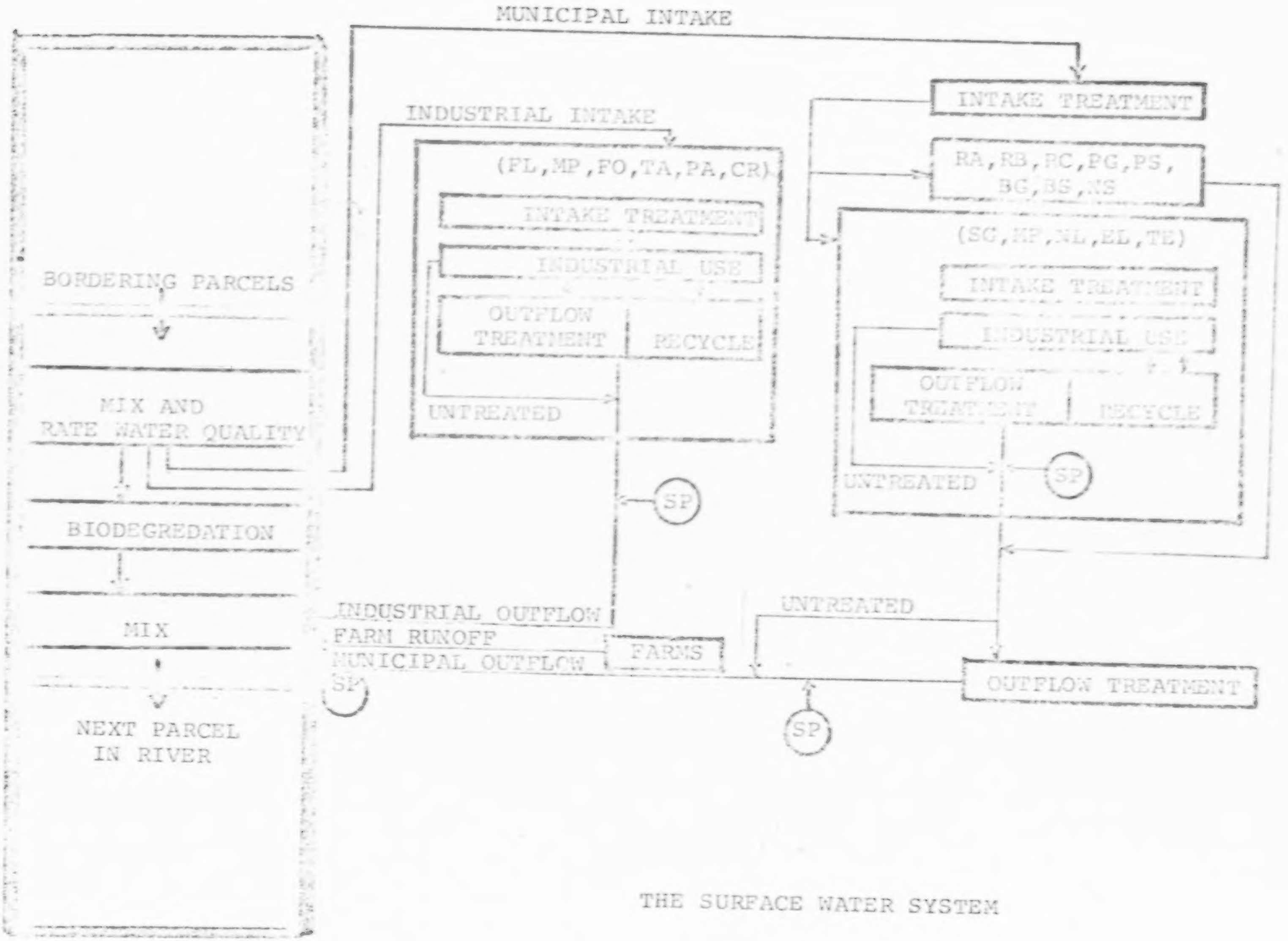
Quality is the only characteristic of surface water which can change during a run of the model. The other characteristics (rate of flow, volume, and surface area) are constant.

Water Sampling Stations can be set up to measure the exact pollution content of the water flowing out of parcels. Sampling stations can also be established to measure the pollution content of water generated by either individual economic activities or municipal systems. The operation of a sampling station is charged to the Utility Department of the jurisdiction in which the station is located.

The figure on the next page illustrates the processes which affect surface water pollution. The pollution flowing into a parcel from adjoining parcels is mixed in the water on the parcel. The pollution concentration per MGD is then measured and the water is rated in one of the nine water quality categories. The water quality rating is the worst rating category generated in any single pollutant. The rating allows no trade-off between a pollutant which is present in very low concentration and one which is very highly concentrated.

Next, water is removed if there are any intaking activities on the parcel. There are two types of intaking activities: 1) basic industries of the types which require surface water; and 2) municipal intake points. There can be only one economic activity on a parcel, and if it is a surface water user, it intakes and dumps on the parcel on which it is located. Municipal intake water is sent to the municipal intake treatment plant and from there to activities served by the district.

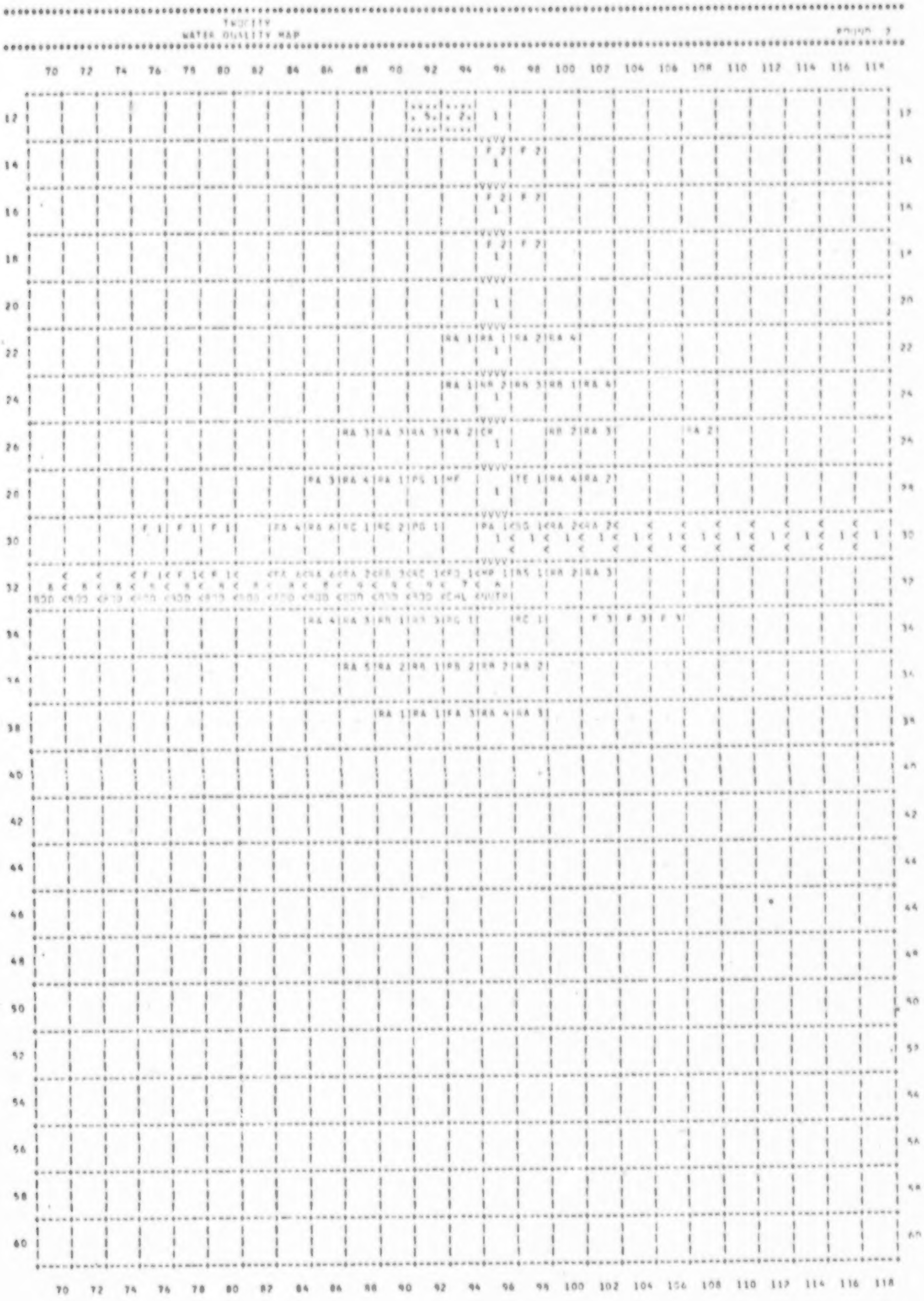
The surface water which is not removed undergoes a biological change process in which some of the pollutants decay naturally. That water is mixed with any water dumped on the parcel. There are three types of activities which can dump on a parcel. In addition to basic industries


MUNICIPAL INTAKE
INDUSTRIAL INTAKE
BORDERING PARCELS
MIX AND RATE WATER QUALITY
BIODEGREDATION
MIX
NEXT PARCEL IN RIVER
(FL,MP,FO,TA,PA,CR)
INTAKE TREATMENT
INDUSTRIAL USE
OUTFLOW TREATMENT
RECYCLE
UNTREATED
SP
INTAKE TREATMENT
RA,RB,RC,PG,PS, BG,BS,NS
(SG,MP,NL,EL,TE)
INTAKE TREATMENT
INDUSTRIAL USE
OUTFLOW TREATMENT
RECYCLE
UNTREATED
SP
INDUSTRIAL OUTFLOW
FARM RUNOFF
MUNICIPAL OUTFLOW
SP
FARMS
UNTREATED
SP
OUTFLOW TREATMENT

THE SURFACE WATER SYSTEM

(SP) = Sampling Point Possible

Figure 10.8


TWOCITY
WATER QUALITY MAP
ROUND 2
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60

```
PARCELS
-------
   TOP ROW: ECONOMIC ACTIVITY TYPE
            AND OPERATING LEVEL
            FARM TYPE IF FARM ON PARCEL
MIDDLE ROW: SURFACE WATER QUALITY RATING
BOTTOM ROW: WORST POLLUTANT

****
****  LAKE PARCELS
****

PARCEL CODES
------------
>AV<  DIRECTION OF FLOW

----  NO WATER FLOWING
      BETWEEN PARCELS
```

and municipal outflow points, farm runoff can add to the pollution on a parcel. Whereas basic industries and municipalities can treat their effluent and thus remove some or all of their pollution, farm pollution can be cut back only if the farm owner decreases the amount of fertilizer used on the farm. The total amount of pollution is then moved on to the next parcel in the river.

The water quality map shows where rivers and economic activities are located in addition to water quality.

Water Usage Map

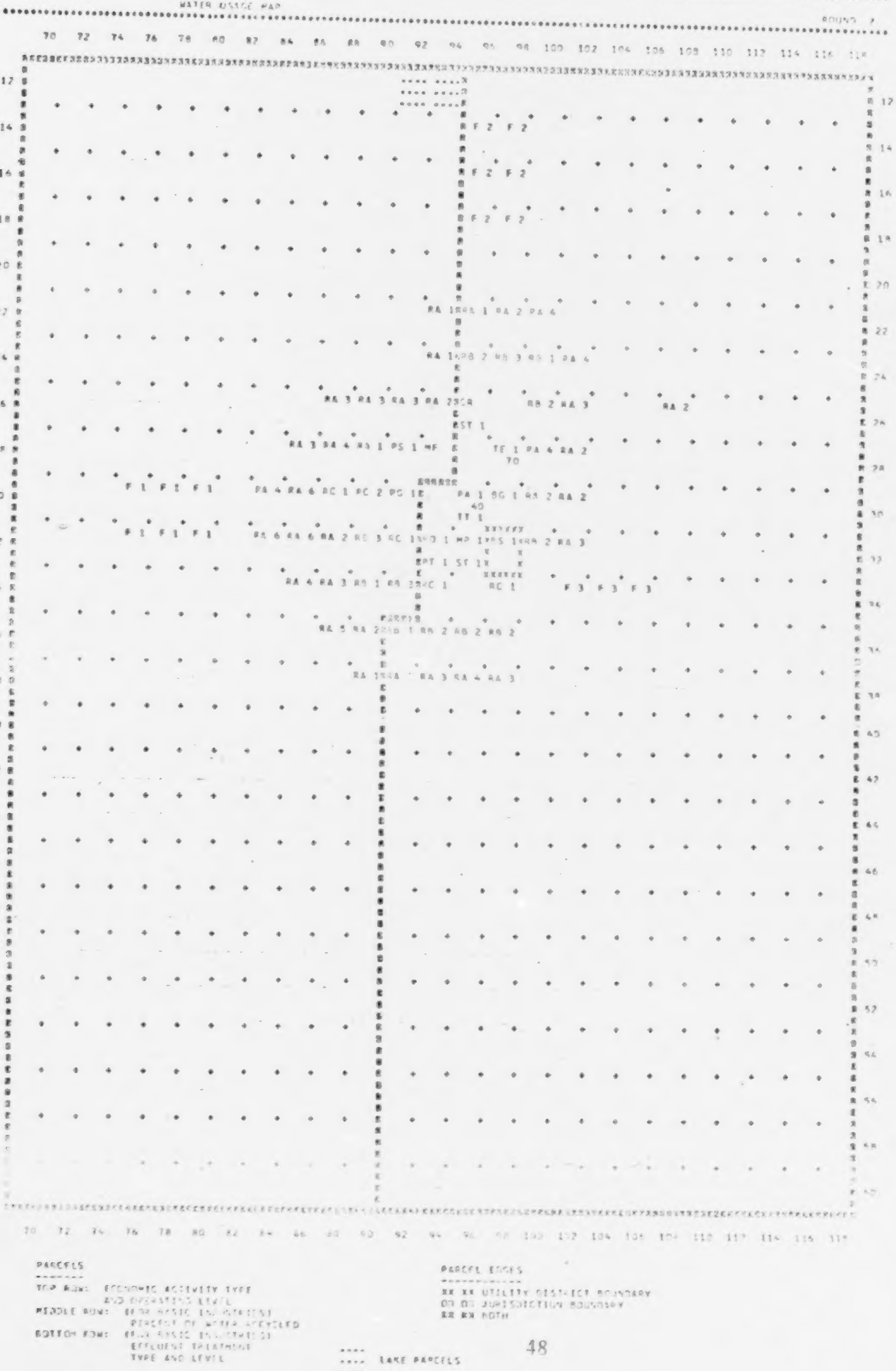
Basic industries can treat their effluent in order to remove pollutants. An industry's effluent treatment plant is located on the same parcel as the industry and does not consume land. Like municipal effluent treatment plants, industrial treatment plants can be of four types: chlorination (CL), primary treatment (PT), secondary treatment (ST), and tertiary treatment (TT). Industrial treatment plants can be constructed to any level and each treatment plant level has the capacity to treat all of the effluent of a level of the industry type which it is constructed to serve. The construction cost of a level of treatment plant varies by treatment type and type of industry.

Industries can recycle up to half of their effluent. Recycled water is not processed through an effluent treatment plant. Its treatment is a process distinct from industrial intake or outflow treatment and costs a fixed number of dollars per MG recycled. So, a level two industry at a recycle level of 100% and having a level one effluent treatment plant treats all of the water which it dumps. If the recycle level under those conditions were 50%, then the industry would treat only two-thirds of the amount which it dumped and one third would be dumped untreated.

Unlike municipal water intake treatment facilities, industrial intake treatment is assumed to exist when the industry is constructed and it is assumed to have the capacity to treat all of the water required by the industry. Like municipal intake treatment costs, industrial intake treatment costs increase as water quality worsens, and the worst water (quality 9) cannot be treated. The industry is forced to pay a high cost for water, the cost represented by the Outside price of water. Furthermore, intake water quality affects the depreciation of surface water users, a reflection of wear on treatment equipment.

NOTE: Regardless of the amount of recycling, intake water quality has the same effect on industrial depreciation. The volume treated does not matter. The assumption is that recycled water goes through intake treatment, so no wear and tear on treatment equipment has been avoided.

Figure 10.7


TWOCITY
WATER USAGE MAP
ROUND 2
PARCELS
TOP ROW: ECONOMIC ACTIVITY TYPE AND OPERATING LEVEL
MIDDLE ROW: (FOR BASIC INDUSTRIES) PERCENT OF WATER RECYCLED
BOTTOM ROW: (FOR BASIC INDUSTRIES) EFFLUENT TREATMENT TYPE AND LEVEL
LAKE PARCELS
PARCEL EDGES
XX XX UTILITY DISTRICT BOUNDARY
OO OO JURISDICTION BOUNDARY
BB BB BOTH

Municipal Services Map

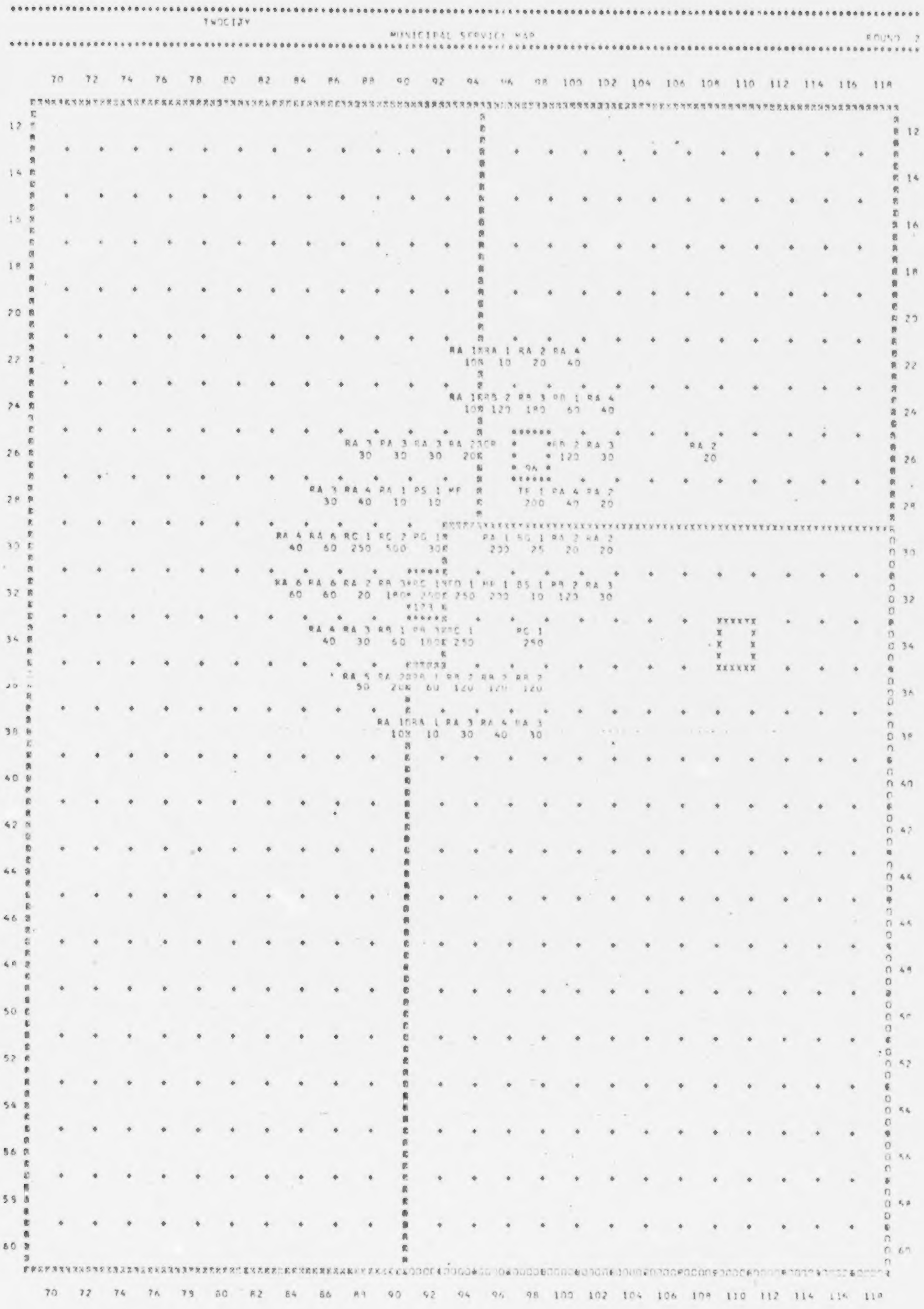
This map designates the jurisdictional boundaries (000) and the district boundaries (xxx) for all municipal service districts within each jurisdiction. Municipal service districts are groups of contiguous parcels that are within the service area of a municipal service (MS) plant. There may be parcels of land that are not contained within a MS district.

The information contained on a land parcel shows the private land use and constructed level and the number of MS units required by this private land use. The MS use index is shown on those parcels on which a MS plant is located. The parcel locations of MS plants are also indicated by surrounding asterisks (***).

Private land uses require the number of MS units indicated in the MS Master Table. Each land use receives the number of units of service it requires, but the quality of the MS service is based upon the ratio of units demanded within a district to the units that are available to the MS plant given its level, value ratio, and employment mix. This ratio is called the MS Use Index, and as it rises above 100 the quality of service declines.

The MS Use Index affects the neighborhood index (neighborhood dissatisfaction) which in turn affects migration and housing selection; the Use Index also affects the rate at which private developments decline in value each round.

Figure 10.4


TWOCITY
MUNICIPAL SERVICE MAP
ROUND 2
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
RA 1 RA 1 RA 2 RA 4
10 10 20 40
RA 1 RB 2 RB 3 RB 1 RA 4
10 120 180 60 40
RA 3 RA 3 RA 3 RA 2
30 30 30 20
RB 2 RA 3
120 30
96
RA 2
20
RA 3 RA 4 RA 1 PS 1 MF
30 40 10 10
TF 1 RA 4 RA 2
200 40 20
RA 4 RA 6 RC 1 RC 2 PG 1
40 60 250 500 30
RA 1 SG 1 RA 2 RA 2
200 25 20 20
RA 6 RA 6 RA 2 RA 3 RC 1 FD 1 MF 1 BS 1 RB 2 RA 3
60 60 20 180 200 250 200 10 120 30
173
RA 4 RA 3 RB 1 RA 3 RC 1
40 30 60 180 250
RC 1
250
RA 5 RA 2 RA 1 RB 2 RB 2 RB 2
50 20 60 120 120 120
RA 1 RA 1 RA 3 RA 4 RA 3
10 10 30 40 30

PARCELS
TOP ROW: LAND USE AND LEVEL
MIDDLE ROW: MS UNITS DRAINED
BOTTOM ROW: MS USE INDEX
(IF MS ON PARCEL)

PARCEL EDGES
XX DISTRICT BOUNDARY
OO JURISDICTION BOUNDARY
8X BOTH
** MS ON PARCEL

School Map

This map designates jurisdictional boundaries (000) and school district boundaries (xxx) for all school districts within each jurisdiction. A school district is a group of contiguous parcels that are within the service area of a school facility. Therefore, every school facility (conceptualized as a collection of elementary and secondary education buildings) has an associated school district. There may be parcels of land that are not served by a public school district. School aged children on these parcels are forced to attend private schools.

The information contained on a parcel of occupied residences shows the number of students attending the local public school (top line) and the number of students attending private schools (middle line). Both of these student figures are expressed in hundreds of students. The School Use Index is shown on those parcels on which a school facility is located. The parcels on which school facilities are located are surrounded by asterisks (***).

Students from high and middle income families will attend the local public schools only if a certain number of school quality criteria are met. Consult the School Master Table for the specific criteria.

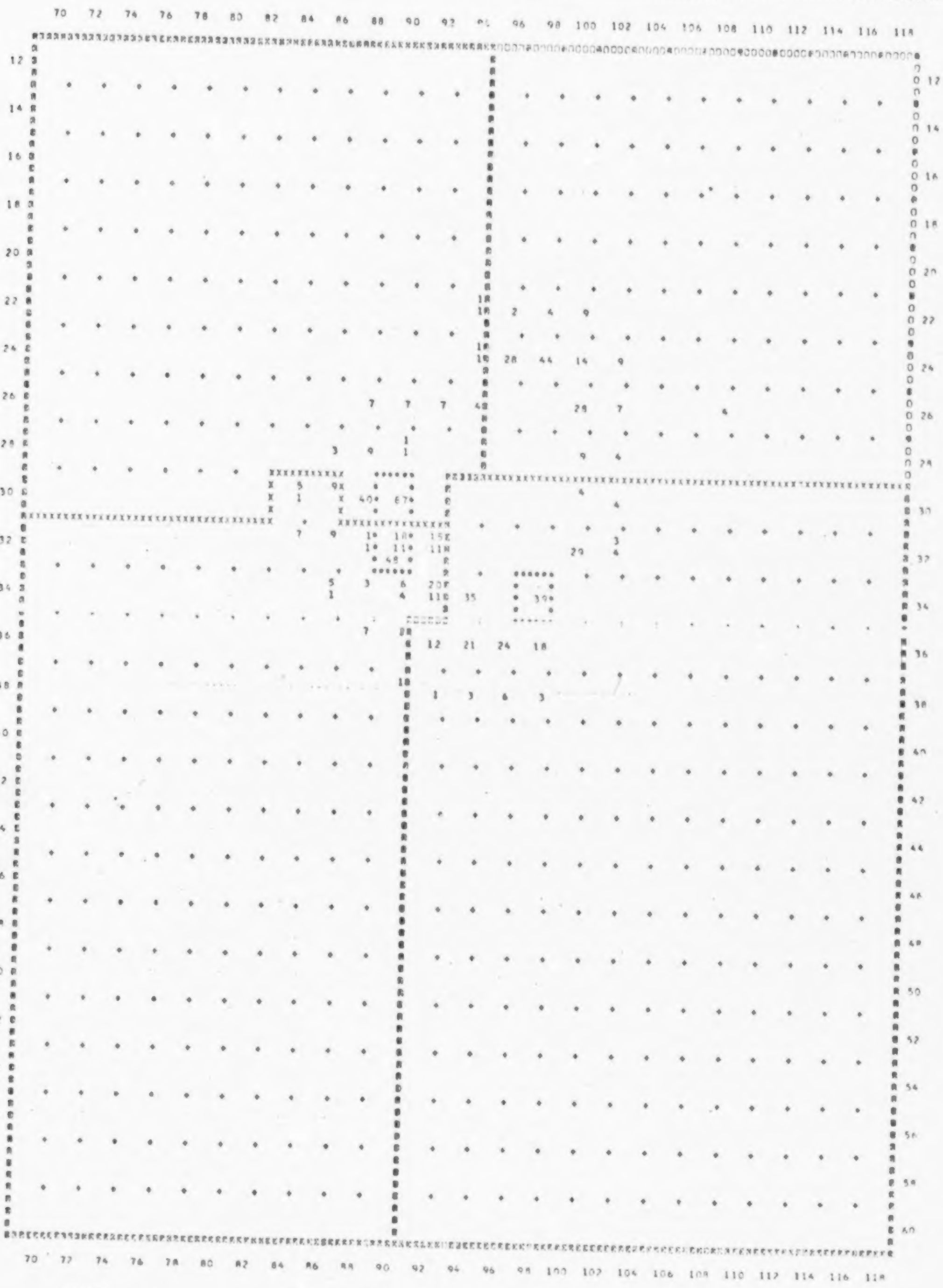
The School Use Index is dependent upon the number of students attending the school district and the capacity of the school district given the level and value ratio of the school facility and the mix of teachers. As this index rises above 100 the quality of public school services declines. The School Use Index affects the neighborhood index (neighborhood dissatisfaction) which in turn affects migration and housing selection.

School district boundaries may be altered by the School Department in an effort to improve the supply-demand balance, serve areas previously not served, and/or change the social class mix of the students attending the public schools.

TWOCITY

SCHOOL MAP

ROUND 2



PARCELS
TOP ROW: PUB SCHL STDNTS
MIDDLE ROW: PRV SCHL STDNTS
BOTTOM ROW: SCHL USE INDEX
(IF SCHL ON PARCEL)
NUMBER OF STUDENTS IN 100'S

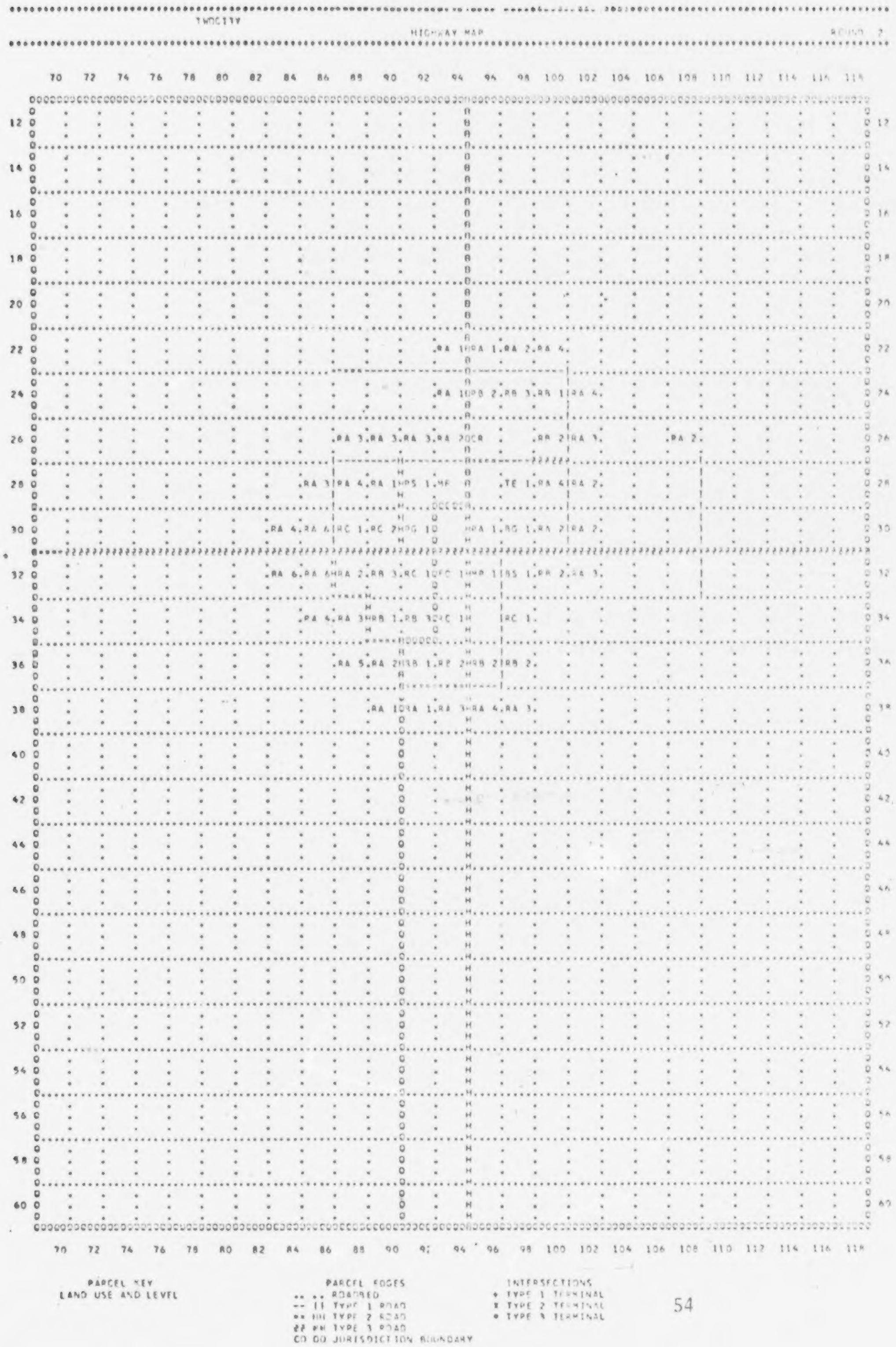
PARCEL EDGES
XX DISTRICT BOUNDARY
OO JURISDICTION BOUNDARY
@@ BOTH
** SCHOOL ON PARCEL

Highway Map

This map designates the location and level of roads and terminals. Roads may be built in the roadbeds which are located along the sides of the parcels of land. Roads may be built at one of three operating levels (1 through 3, with 3 being the largest capacity road). Road locations are identified by a coordinate pair that consists of an even and an odd number. For example, 7011 is the east-west road at the upper left portion of the map and 6912 is the north-south road at the upper left portion of the map. [Roads may not be built along the extreme right boundary (line 119) or along the extreme bottom boundary (line 61) of the map.]

Terminals may be built at one of three service levels (with level 3 being the largest capacity terminal). Terminals are located at the intersections of roads or roadbeds. Business activities that use terminals are assigned to specific terminal locations taking into account accessibility and terminal capacity.

Figure 10.19


TWOCITY
HIGHWAY MAP
ROUND 2
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
PARCEL KEY
LAND USE AND LEVEL
PARCEL EDGES
.. .. ROADBED
-- II TYPE 1 ROAD
** HH TYPE 2 ROAD
ZZ HH TYPE 3 ROAD
CO OO JURISDICTION BOUNDARY
INTERSECTIONS
+ TYPE 1 TERMINAL
X TYPE 2 TERMINAL
* TYPE 3 TERMINAL

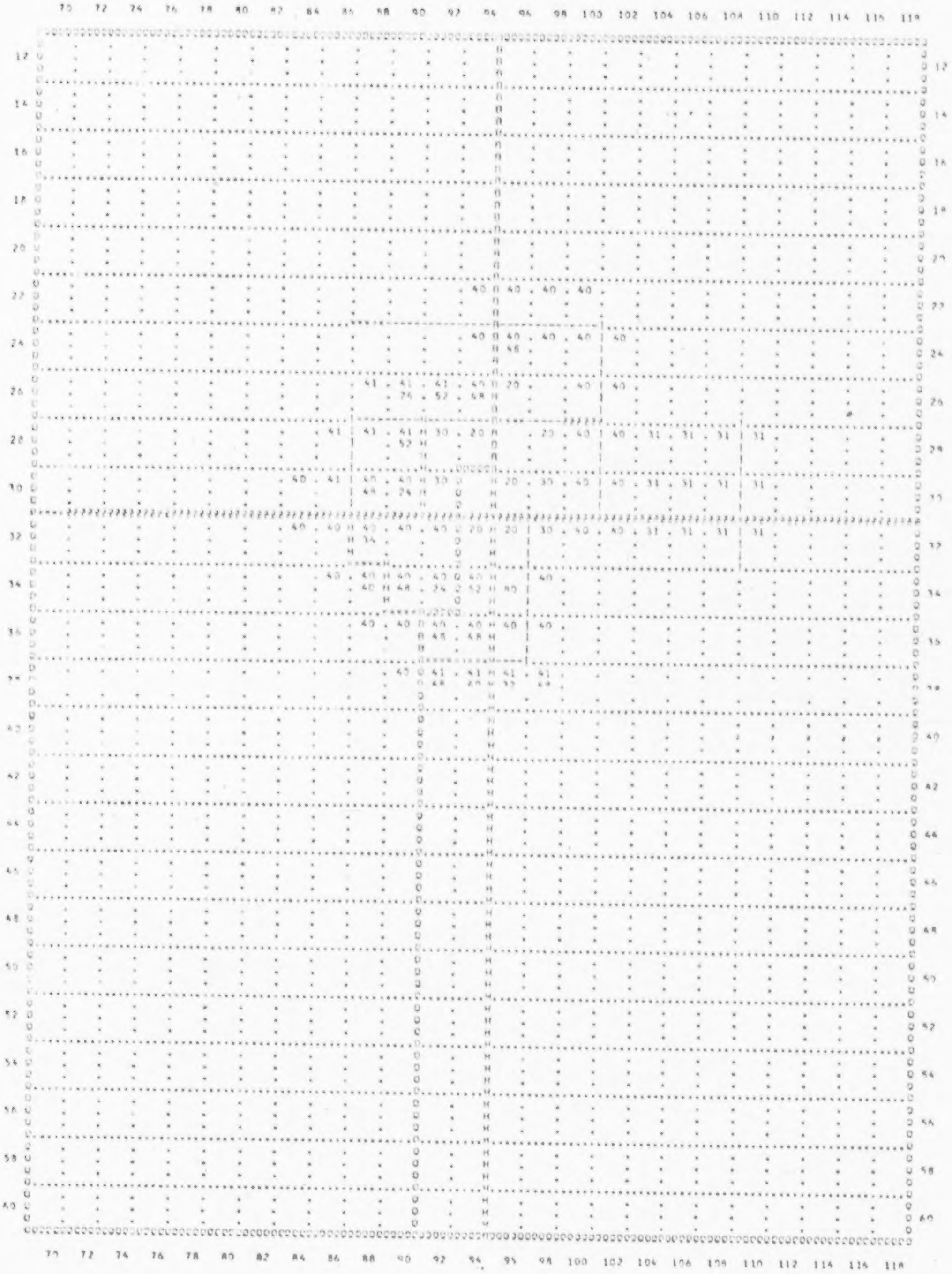
Planning and Zoning Map

This map shows the zoning that is in effect on each parcel of land for which the local jurisdiction has designated a zoning code. New land uses must conform to the zoning classifications. Existing land uses are not forced to change as the result of new zoning classifications that are inconsistent. Parcels that have no zoning do not have any construction limitations placed upon them. The land uses allowed under each zoning classification are shown in the Economic Master Table and in the Planning and Zoning Master Table.

The percent of each parcel devoted to parkland and public institutional land is also shown on the Planning and Zoning Map. Parkland is relatively undeveloped public land that is operated by the Planning and Zoning Department and serves the community in the form of football and baseball fields, picnic areas, hiking trails, and wooded land. Public institutional land contains costly public recreation facilities such as museums, art galleries, libraries, and sports arenas.

This map also shows the road network, terminals and jurisdictional boundaries.

```
                 TWOCITY
                                      PLANNED LAND ZONING MAP                          ROUND  2
```



```
           PARCELS                        PARCEL EDGES                 INTERSECTIONS         ZONING  LAND USE      ZONING  USE
TOP ROW:      ZONING                   .. .. ROADBED                  + TYPE 1 TERMINAL      --   ANY USE           33   RS
MIDDLE ROW: % PARKLAND                 -- II TYPE 1 ROAD              X TYPE 2 TERMINAL      10   ANY BUSINESS      34   RL
BOTTOM ROW: % PUB INST LAND            ** HH TYPE 2 ROAD              * TYPE 3 TERMINAL      20   HI,LI,CI          35   PS
                                       ?? ** TYPE 3 ROAD                                     21   HI                40   RA,RB,RC
                                       OO OO JURISDICTION BOUNDARY                           22   LI                41   RA
                                                                                             23   CI                42   RB
                                                                                             30   NS,RG,RS,PG,PS    43   RC
                                                                                             31   NS                50   PARKLAND
                                                                                             32   RG
```

Parkland Usage Map

This map shows the location and amount of land devoted to parks. Each parcel containing parkland has a number that indicates the percent of the parcel in parks. A "park" is all the parkland on a single parcel regardless of the percent of the parcel devoted to park use. Parkland from two parcels may not be combined into a single "park".

The local population using each park is the second piece of information contained on each parkland parcel. An index value of parkland use is the final piece of information on each park parcel.

The number of people living on a residence parcel is a measure of the demand for parkland by that parcel. This demand is supplied by parks within a 5 by 5 grid centered on that residence parcel. Each park within the grid is assigned a share of the residents on the residence parcel that is proportional to the size of each park relative to the total parkland within the grid. Therefore, assignment to parks is performed from the point-of-view of the residence parcels.

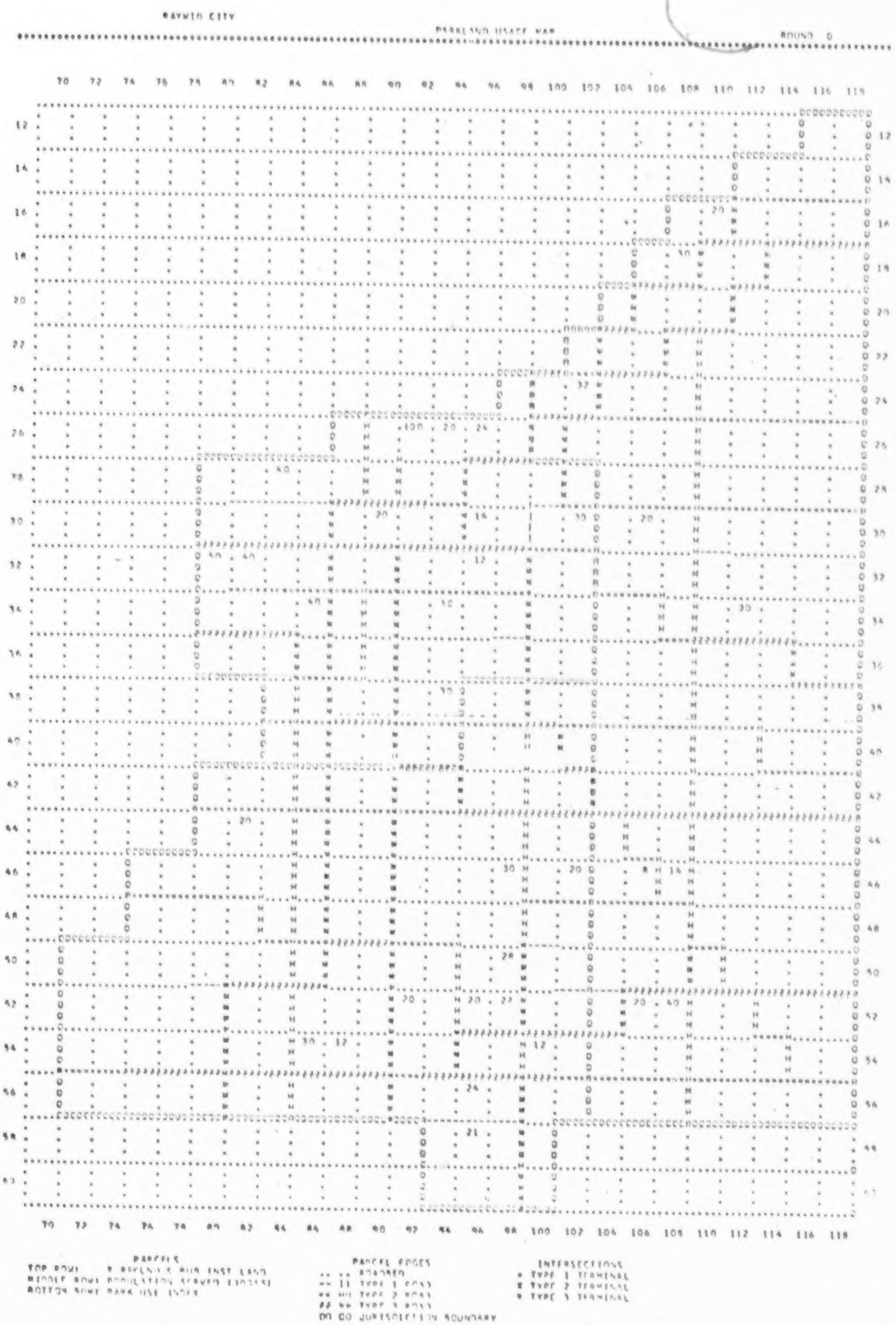
Once all the residence demand has been allocated to parks (residences that have no parks within their 5 by 5 grid are not allocated to parks) the park use index is calculated by dividing the people served by 250 times the normalized percent of the parcel in parkland. The normalized percent of the land in parkland is derived by adding the percent in parkland and two times the percent of the land in public institutional use.

The park use index affects personal dissatisfaction in such a way that poor parks (those with use indices between 100 and 200) tend to diminish the positive effect that units of time spent in recreation has on the personal dissatisfaction index. The park index used by a residence parcel in determining the effect of park service on dissatisfaction is the park with the highest use index within the 5 by 5 grid area. A residence with no park to serve it is assumed to be served by a park with a use index of 200.

When a residence is served by a park with a park use index of 100 or less, the number of units of leisure time allocated by social classes on that parcel (TR = time in recreation) are subtracted from the personal dissatisfaction index. If the park index is greater than 100, the number of units subtracted from the personal dissatisfaction index is equal to the Park Use Index minus 100 (and expressed as a percent) times TR. Thus, if the park Use Index is the worst possible (200) the effect of local park service on the personal dissatisfaction index is zero. Therefore, park service quality has only a one-sided effect on personal dissatisfaction (it may subtract from personal dissatisfaction but never add to it).

This map also shows the road network, terminals, and jurisdictional boundaries.

Figure 10.21


BAYWID CITY
PARKLAND USAGE MAP
ROUND 0
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
PARCELS
TOP ROW: % PARKLAND FOR INST LAND
MIDDLE ROW: POPULATION SERVED (1000'S)
BOTTOM ROW: PARK USE INDEX
PARCEL EDGES
.. .. BOARDER
-- II TYPE 1 ROAD
== HH TYPE 2 ROAD
## ** TYPE 3 ROAD
OO OO JURISDICTION BOUNDARY
INTERSECTIONS
• TYPE 1 TERMINAL
X TYPE 2 TERMINAL
• TYPE 3 TERMINAL

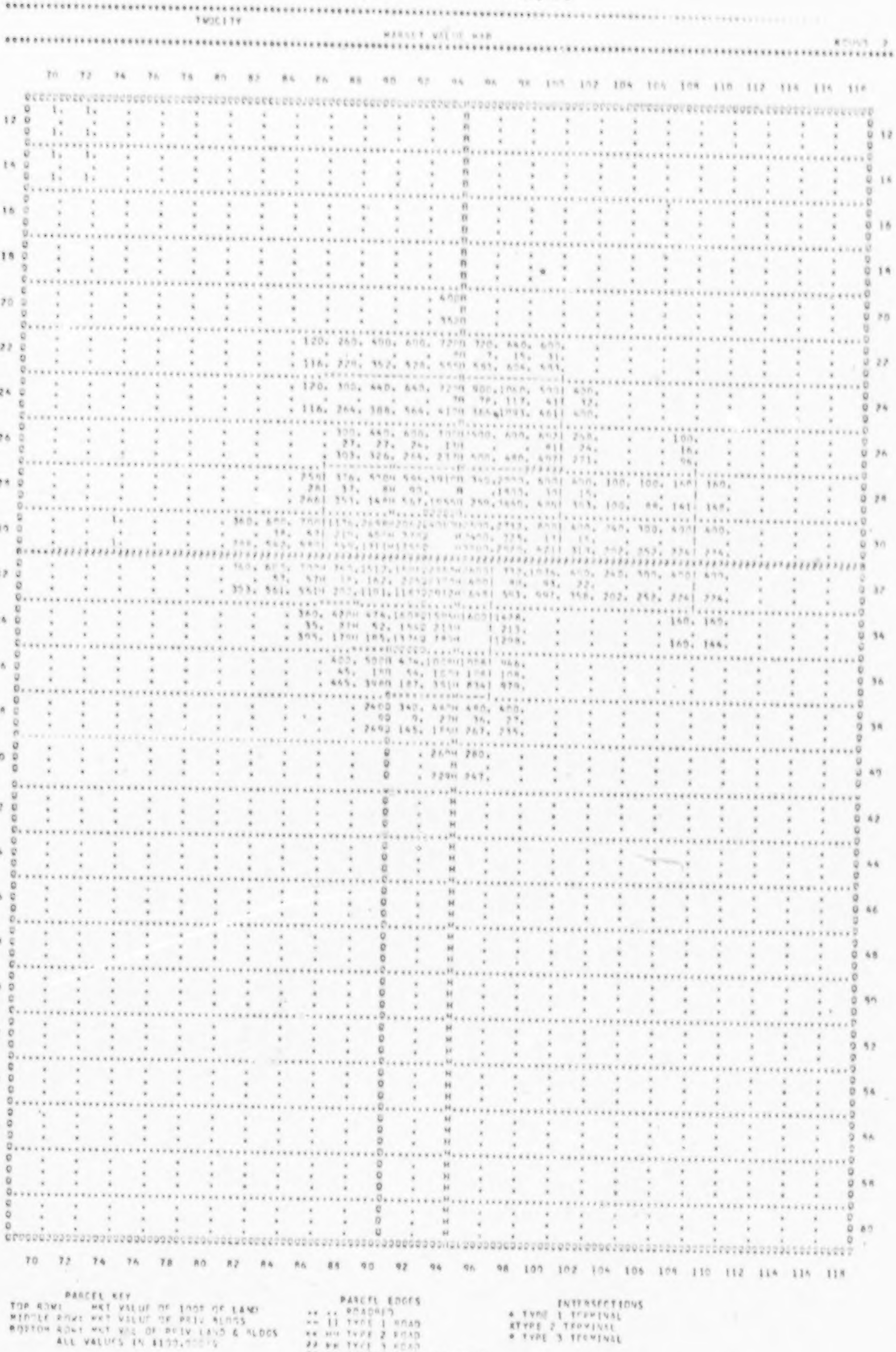
Market Value Map

This map designates the jurisdictional boundaries (000) and the highway system (including terminals). Nonfarm parcels of land that are owned by local decision-makers contain information on the market value of the land and developments on the parcel (values are in $100,000's).

The top row of each such parcel indicates the market value of 100% of the land on the parcel. This value of 100 percent of the land on the parcel is printed so that comparisons may be made from one parcel to another without having to take into consideration what percent of each parcel is privately owned. Since there is usually some land on most parcels that is not privately owned, the actual market values of the land will be somewhat less than indicated on the map. Nonprivate uses of the land might be for rights of way, schools, municipal services, utilities, treatment plants, parks, institutional, public undeveloped, water bodies, and topographically undevelopable.

The middle row indicates the market value of all private developments. This value is the normal new value (see Economic Master Table) of each land use times the constructed level times the value ratio.

Figure 10.16


TWOCITY
MARKET VALUE MAP
ROUND 2
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
PARCEL KEY
TOP ROW: MKT VALUE OF 100% OF LAND
MIDDLE ROW: MKT VALUE OF PRIV BLDGS
BOTTOM ROW: MKT VAL OF PRIV LAND & BLDGS
ALL VALUES IN $100,000'S
PARCEL EDGES
.. .. ROADBED
-- II TYPE 1 ROAD
** HH TYPE 2 ROAD
ZZ RR TYPE 3 ROAD
OO OO JURISDICTION BOUNDARY
INTERSECTIONS
+ TYPE 1 TERMINAL
X TYPE 2 TERMINAL
* TYPE 3 TERMINAL

Assessed Value Map

This map shows the assessed values of non-farm land and of developments on the land for those parcels of land that have a private local system owner (i.e., non-farm parcels owned by Economic Teams). The top number on a parcel square is the assessed value of 100% of the land.

Assessed values of land are created in two ways: first, land that is newly purchased at a price higher than the previous market value is given a new market value equal to the sale price and a new assessed value that is dependent upon the jurisdiction's developed land assessment ratio or undeveloped land assessment ratio, depending on whether there is any economic activity on the parcel; second, through local assessment policy. The local assessment policy can change the value by altering the land assessment ratio (either jurisdiction-wide or by parcel) or inputting a dollar amount (this decision only lasts for one round).

The second number is the assessed value of the development on the parcel. If no number appears in this position, the land is still undeveloped. Assessed values of developments are changed through new constructions, declining market values of developments (resulting from declining value ratios), and changes in the development assessment ratios. The Assessment Department may change the assessed values of developments by changing the jurisdiction-wide development assessment ratios, changing the development assessment ratio for specific parcels, or by inputting a dollar value of the development assessment (this decision lasts for only one round and must be input each round for which the dollar assessed value is to remain the same).

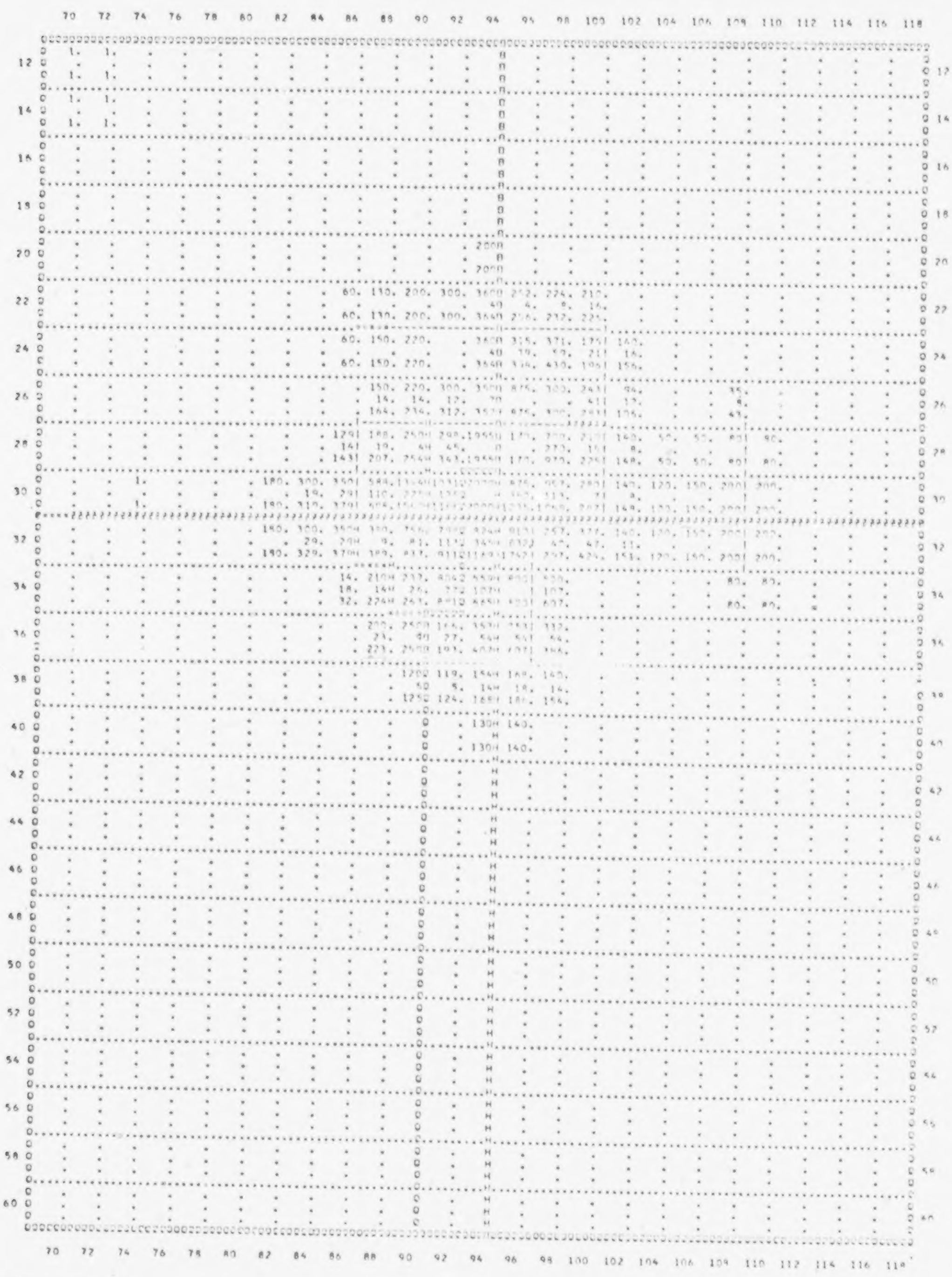
The last line on a privately-owned land parcel shows the total (land and development) assessed value. The dollar values on this map are expressed in a scale factor ($1m; $100,000; or $10,000) that is chosen by the computer based upon the highest and lowest dollar values represented on the map. Therefore, the map key is adjusted automatically when the need arises.

This map also shows jurisdictional boundaries, the road netowrk, and the location of terminals.

Figure 10.17

TWOCITY

ASSESSED VALUE MAP ROUND 2



PARCELS
TOP ROW: ASSESSED LAND VALUE
MIDDLE ROW: ASSESSED BLDG VALUE
BOTTOM ROW: TOTAL ASSESSED VALUE
ALL VALUES IN $100,000

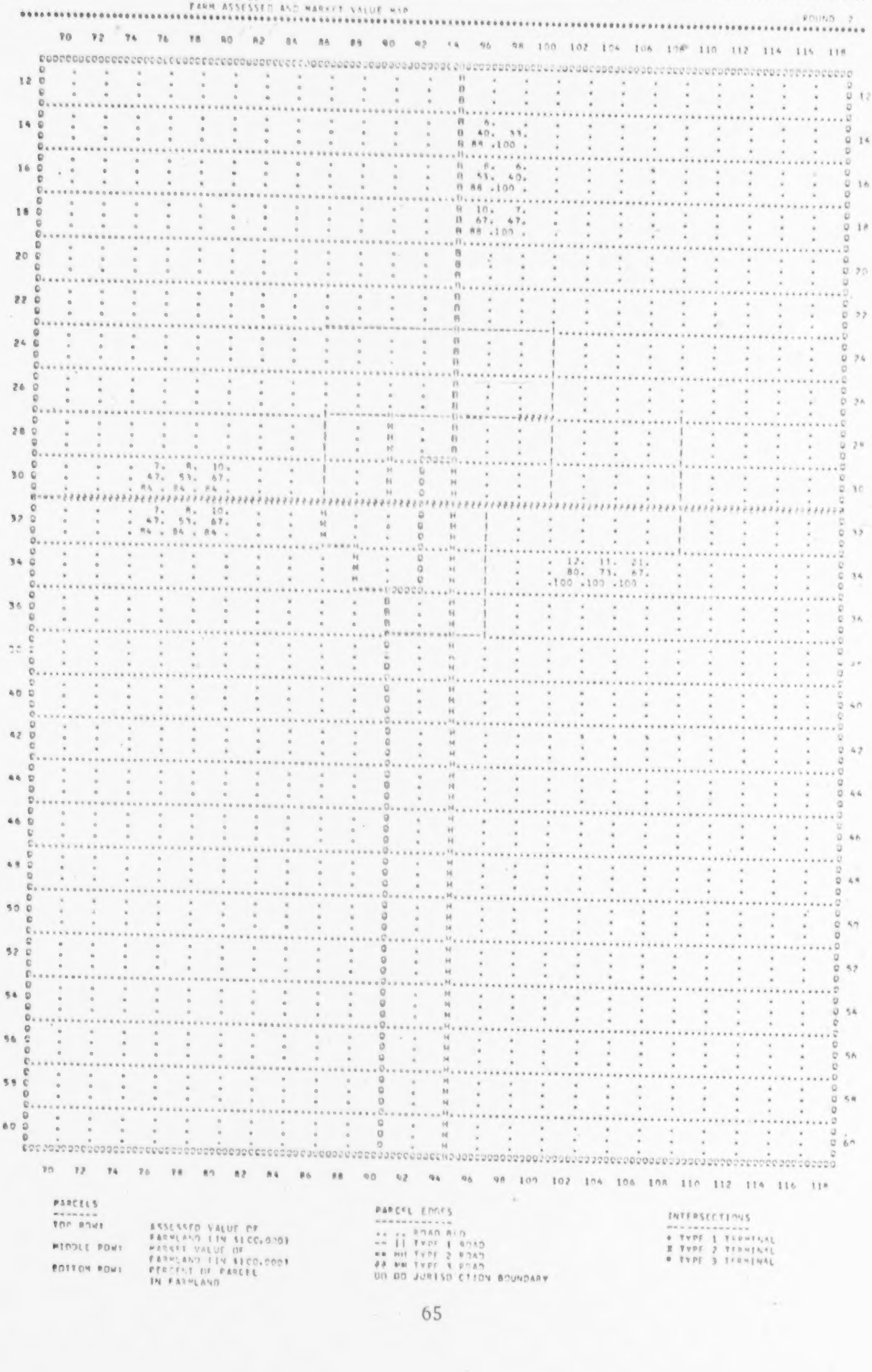
PARCEL EDGES
.. .. ROADSED
-- II TYPE 1 ROAD
** HH TYPE 2 ROAD
?? WW TYPE 3 ROAD
OO OO JURISDICTION BOUNDARY

INTERSECTIONS
• TYPE 1 TERMINAL
I TYPE 2 TERMINAL
• TYPE 3 TERMINAL

Farm Assessed and Market Value Map

The value shown for a farm parcel on the map is for that portion of a parcel which is in farm use. The ratio of assessed value to market value is set by the Assessor of the jurisdiction in which a farm is located. A farm owner pays local property taxes at the rate set by the Chairman and on the base set by the Assessor of the jurisdiction in which the farm is located. Since a farm's net income before taxes is fixed according to the farm's fertilizer level, the amount of land at the farm and the farm type, the only variable expenditure is local property tax.

Figure 10.15



```
                    TWOCITY
           FARM ASSESSED AND MARKET VALUE MAP
                                                                   ROUND 2

PARCELS                                     PARCEL EDGES                       INTERSECTIONS
-------                                     ------------                       -------------
TOP ROW:      ASSESSED VALUE OF             .. .. ROAD BID                     * TYPE 1 TERMINAL
              FARMLAND (IN $100,000)        -- || TYPE 1 ROAD                  # TYPE 2 TERMINAL
MIDDLE ROW:   MARKET VALUE OF               == HH TYPE 2 ROAD                  * TYPE 3 TERMINAL
              FARMLAND (IN $100,000)        ## NN TYPE 3 ROAD
BOTTOM ROW:   PERCENT OF PARCEL             OO OO JURISDICTION BOUNDARY
              IN FARMLAND
```

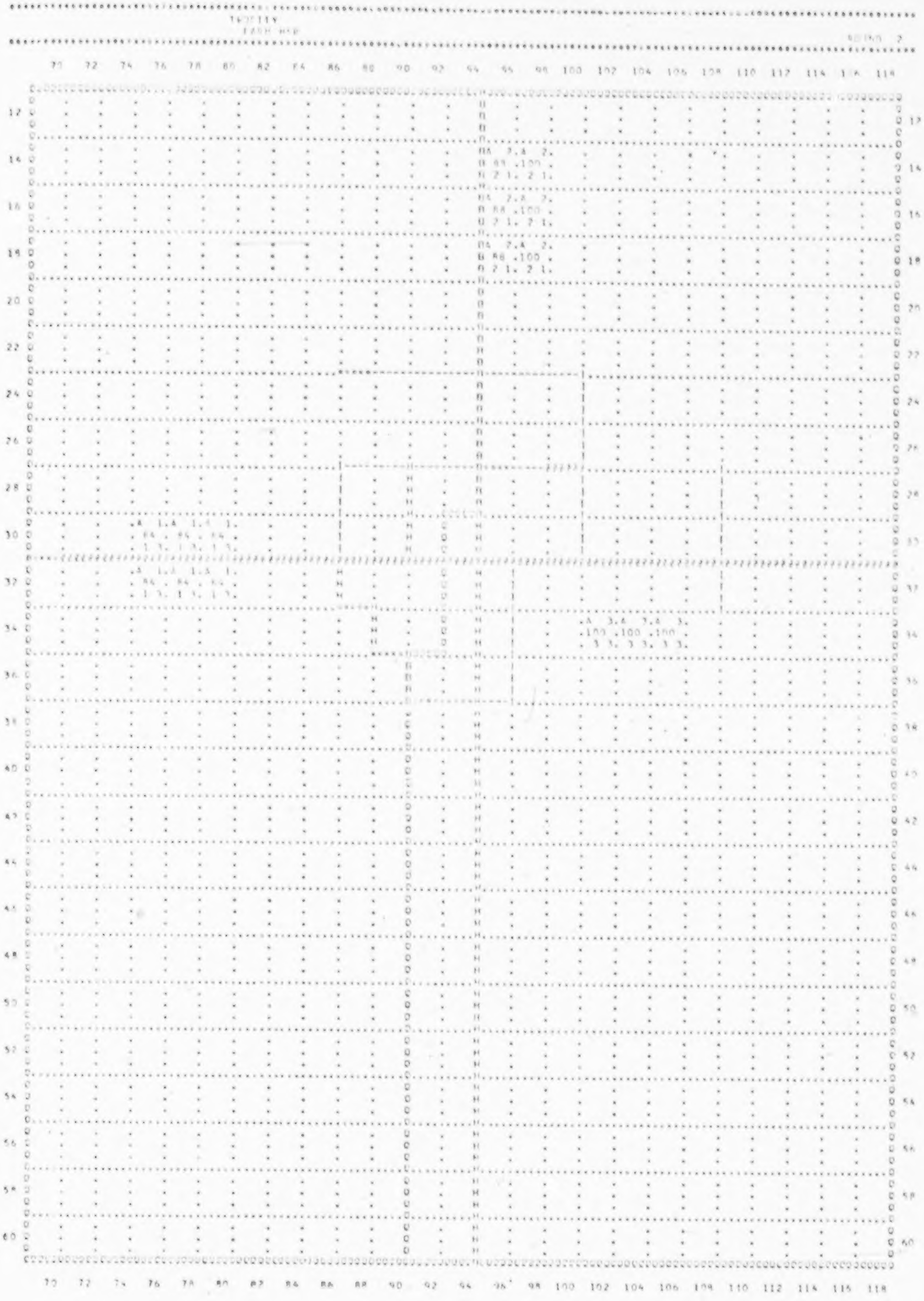
Farm Map

A farm can contain more than one parcel. All of the parcels in a single farm have the same owner, farm code number, farm type, and fertilizer level. The amount of land in farm use may be different for the different parcels in a single farm. The rest of the land can be in public use or can be topographically unusable. No other economic activity can be located on a farm parcel, and all of the farmland on a single farm parcel is of the same farm type. When the economic owner of a farm parcel changes, the parcel ceases to be classified as a farm. Once an initial starting configuration of the board has been selected, no farms can be created.

There are two types of decisions which a farm owner can make: set the fertilizer level for a farm; and sell part or all of the farmland on a farm.

A farm's fertilizer level is an integer from 0 to 3. Associated with each of the four fertilizer factors is a multiplierwhich represents the increase in normal income which occurs at that fertilizer factor for the farm type. There is also an associated amount of pollution in the runoff resulting from each fertilizer factor. Volume of runoff stays the same for a farm parcel regardless of the amount of land on that parcel in farm activity. When a parcel is no longer a farm, no more runoff exists. A farm owner's income increases as he sets a higher fertilizer factor level. Likewise, the amount of pollution on a farm's runoff increases with the fertilizer level.

Figure 10.14


FARM MAP
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60

```
PARCELS                                PARCEL EDGES                        INTERSECTIONS
-------                                ------------                        -------------
TOP LEFT:      OWNER                   .. .. ROAD END                      * TYPE 1 TERMINAL
TOP RIGHT:     FARM CODE NUMBER        -- II TYPE 1 ROAD                   X TYPE 2 TERMINAL
MIDDLE:        PERCENT OF PARCEL       ** HH TYPE 2 ROAD                   # TYPE 3 TERMINAL
               IN FARMLAND             ZZ WW TYPE 3 ROAD
BOTTOM LEFT:   FARM TYPE               DD DD JURISDICTION BOUNDARY
BOTTOM RIGHT:  UTILIZED LEVEL
```

Farm Runoff Map

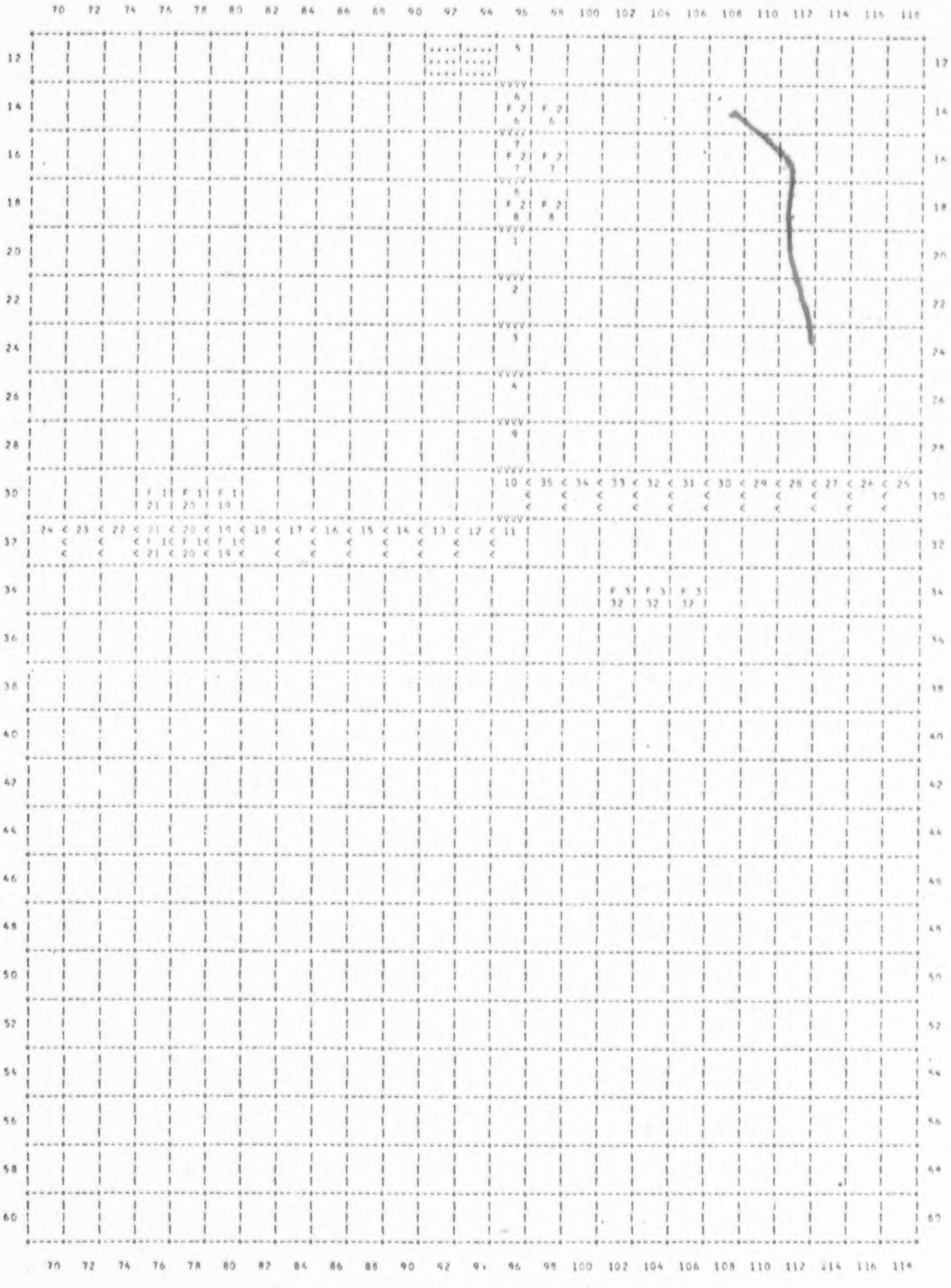
Farms do not use surface water or municipally-supplied water. Their water requirements are assumed to be met by rain or ground water. However, some of the water which falls on farms runs into the surface water. Farms use fertilizer, and those nutrients flow into the surface water in farm runoff. The Farm Runoff Map shows where farm runoff flows. The program assigns each surface water parcel a code number, which is printed on the top row of parcels containing surface water. Wherever there is a farm, the middle row shows 'F' and the farm type. Different types of farms have different basic fertilizer requirements and net incomes from sales. On a farm parcel the bottom row of the parcel shows the code number of the surface water parcel on which the farm parcel's runoff flows.

A farm owner sets a level of fertilizer use for the farm. The higher the fertilizer level, the greater the concentration of nutrients in the runoff from the parcels comprising the farm.

Figure 10.12

TWOCITY
FARM RUNOFF MAP

ROUND 2


70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114 116 118
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
5
6
F 2
7
8
1
2
3
4
9
10 < 35 < 34 < 33 < 32 < 31 < 30 < 29 < 28 < 27 < 26 < 25
F 1
21
20
19
24 < 23 < 22 < 21 < 20 < 19 < 18 < 17 < 16 < 15 < 14 < 13 < 12 < 11
F 3
32

PARCELS

TOP ROW: (FOR SURFACE WATER PARCELS)
CODE NUMBER OF PARCEL
MIDDLE ROW: FARM TYPE
BOTTOM ROW: PARCEL WHERE RUNOFF FLOWS

PARCEL EDGES

>AV< DIRECTION OF FLOW
---- NO WATER FLOWING
BETWEEN PARCELS

River Basin Flood Plain Map

Each parcel has a flood susceptibility between 0 and 3 representing the parcel's likelihood of suffering damage due to its location when a flood occurs in its river basin. A parcel with zero flood susceptibility remains undamaged when there is a flood, and a parcel with a flood susceptibility of 3 suffers the flood's worst damage.

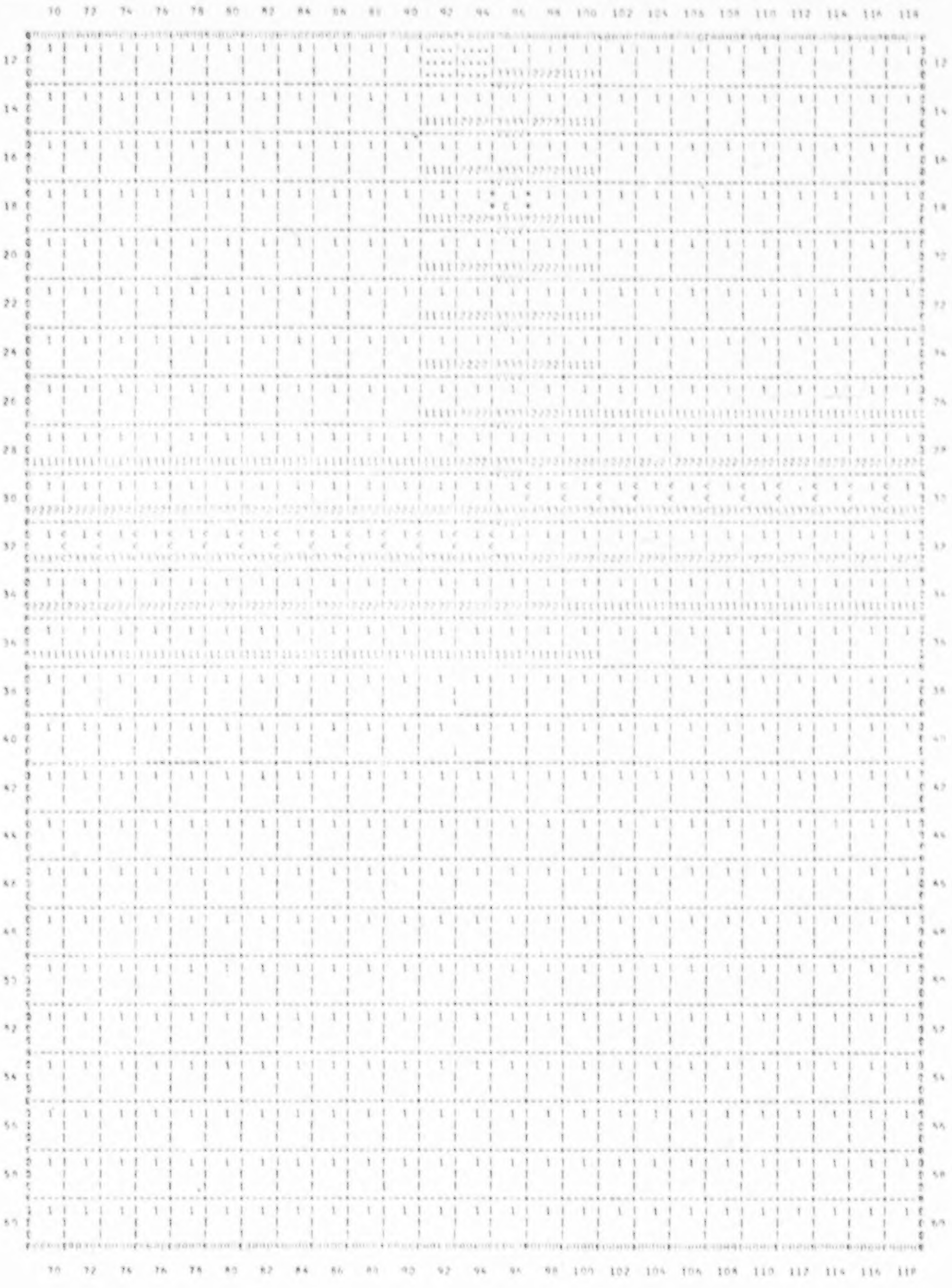
The game director controls the time of occurrence and severity of floods. When a flood occurs, it affects the depreciation of businesses and residences located on parcels with non-zero flood susceptibilities. The degree of damage done to a business or residence by a flood is a function of the severity of the flood as input by the director, the parcel's flood susceptibility, the type of economic activity, and the dam priority of the river basin in which the parcel is located. A river basin's dam priority (A, B, or C) represents the major purpose of the operation of the dams in that river basin. The three sets of priorities involve trade-offs among flood control, pollutant concentrations, and water availability for major recreation areas.

Each of the four factors in degree of damage has an associated numerical value. All four are multiplied together in the calculation of degree of damage.

TAPESTRY

RIVER BASIN-FLOOD PLAIN MAP

ROUND 1


70
72
74
76
78
80
82
84
86
88
90
92
94
96
98
100
102
104
106
108
110
112
114
116
118
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52
54
56
58
60

PARCELS

TOP ROW: CODE NUMBER OF RIVER BASIN
MIDDLE ROW: [illegible]
BOTTOM ROW: FLOOD SUSCEPTIBILITY
****
**** LAKE PARCELS
****

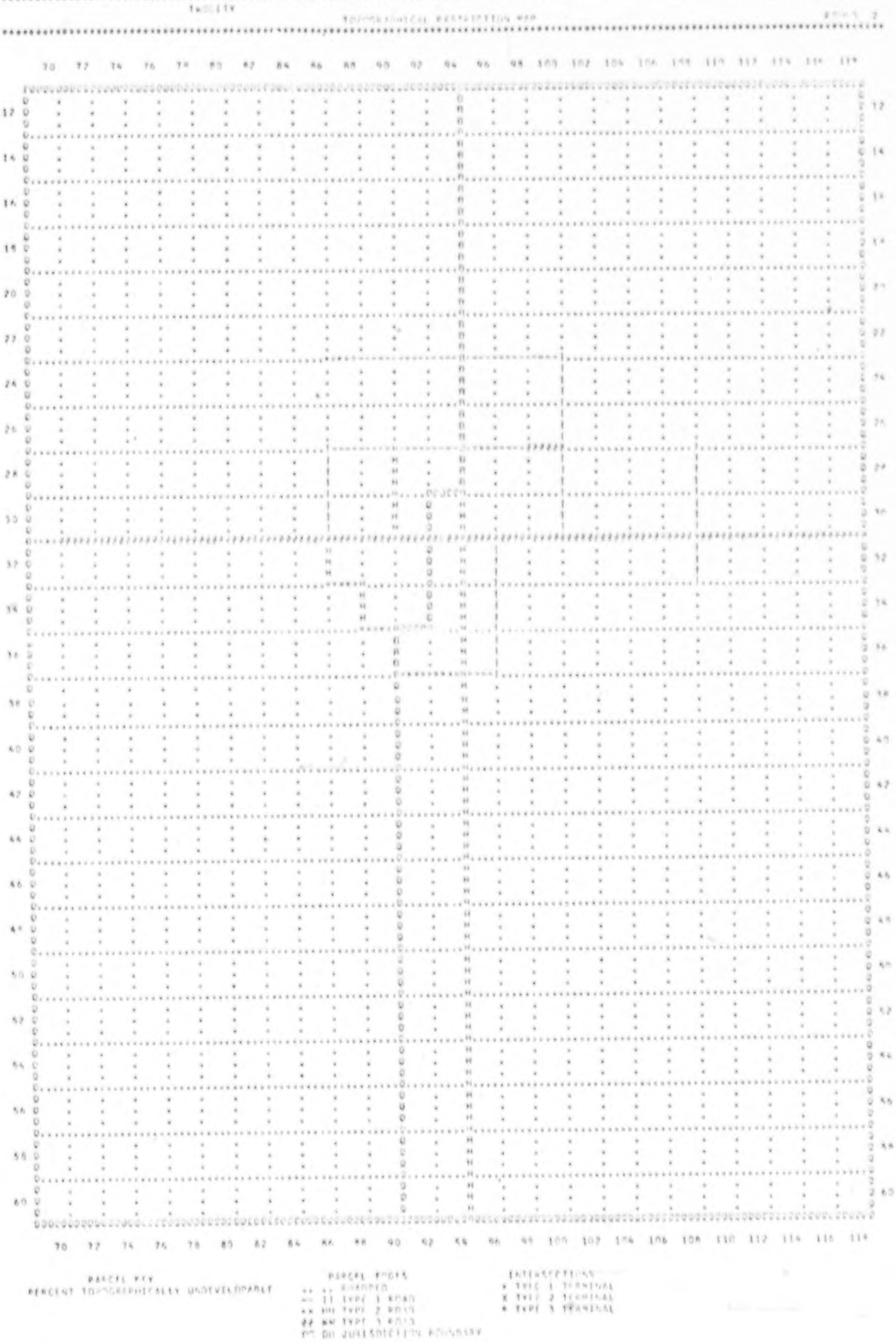
PARCEL EDGES

[illegible] DIRECTION OF FLOW
---- NO WATER FLOWING
      BETWEEN PARCELS
**** DAM ON PARCEL
DDDD RIVER BASIN BOUNDARY

Topographical Restriction Map

This map shows the percent of a parcel that may not be purchased or developed by any local decision-makers. Land that is topographically undevelopable includes mountains, rock outcrops, swamps. None of the area consumed by water bodies represented in the local system (large lakes, small lakes, and rivers) is shown on this map. The map also shows jurisdictional boundaries, the road network, and the location of terminals.

Figure 10.25

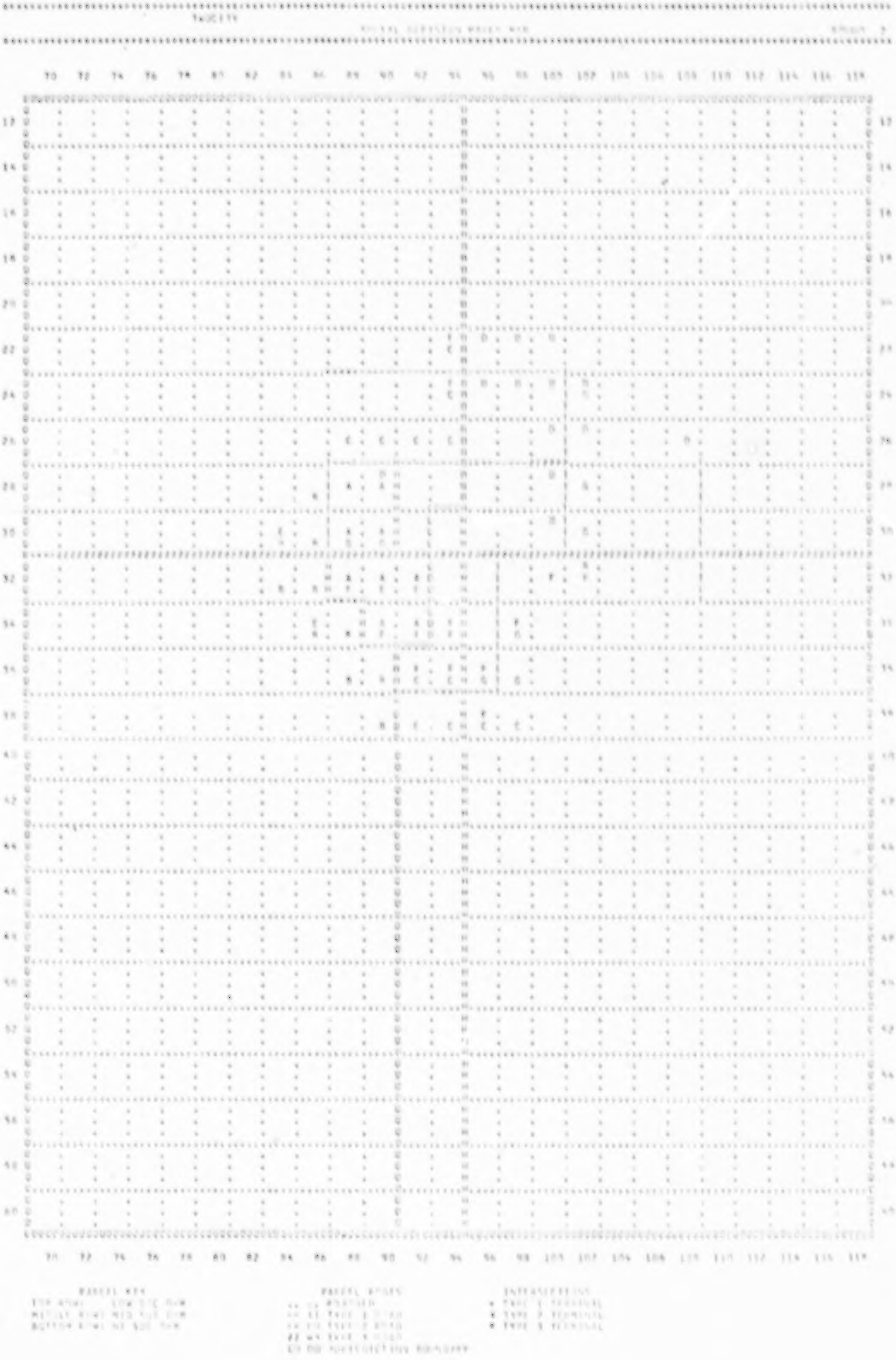

TOPOGRAPHICAL RESTRICTION MAP
PARCEL KEY
PERCENT TOPOGRAPHICALLY UNDEVELOPABLE
PARCEL EDGES
.. .. BORDERED
== II TYPE 1 ROAD
** HH TYPE 2 ROAD
## NN TYPE 3 ROAD
00 DD JURISDICTION BOUNDARY
INTERSECTIONS
+ TYPE 1 TERMINAL
X TYPE 2 TERMINAL
* TYPE 3 TERMINAL

Social Decision Maker Map

This map indicates which social players make decisions for the low, middle, and high income population units on parcels. The top letter on a given parcel represents the social decision-maker who controls the PL's who live there, and the middle and lower letters represent the social decision-makers who control the PM's and PH's, respectively, who live there. If a particular class does not live on a parcel, no letter is printed.

Not until a parcel is developed for residential land use and occupied by at least one income class, will a social decision-maker for that parcel appear on the map. Note that different decision-makers may control the different population classes on a single parcel. Social teams acquire control over additional Pl's on a parcel when the number of Pl's of that class moving into the parcel exceeds the number moving out. Social teams may find that from round to round they gain or lose control of population units on a residential parcel of land. This occurs as a result of the migration of Pl's of a class to a parcel where previously there were no Pl's of that class (a gain) or as a result of the migration away from a parcel of all the Pl's of a class on that parcel.

Figure 10.24


70
72
74
76
78
80
82
84
86
88
90
92
94
96
98
100
102
104
106
108
110
112
114
116
118
PARCEL KEY
PARCEL EDGES
INTERSECTIONS

C. Summary Information

1. Demographic and Economic Statistics

The output summarizes a wide variety of information about the simulated region. There are two basic types of information: statistics by jurisdiction and for the region as a whole about local conditions, and measures of interactions between the region and the Outside System. The former provide comparisons between jurisdictions; the latter provide comparisons between the local and Outside systems.

Statistics Regarding Local Conditions

Total population: the number of people (not Pl's), by class.

Percent change over previous year: the total population change, positive or negative, between the current round and the previous round. This is the only local statistic which is given only as a total and not broken down by jurisdiction.

Average population per parcel: the number of people divided by the number of parcels.

Developed land (in parcels): the amount of land area (in parcel equivalents) consumed by public and private developments.

Undeveloped land: the amount of land area (in parcel equivalents) not consumed by developments.

Total land area: the number of parcels.
Assessed value of land in millions: the property tax base.
Assessed value of developments in millions: the development tax base.

Average quality of life index: a measure across classes of the people's average quality of life index. The higher the index, the poorer the quality of life. The indexes may differ significantly within a jurisdiction, but only averages are given here.

Number of registered voters: the number of people eligible to vote, from which the number who actually vote are selected.

Figure - 9.1

```
   TWOCITY                                                                                                  ROUND  1
                 DEMOGRAPHIC AND ECONOMIC STATISTICS
****************************************************************************************************************************

                                                                   JURISDICTION   JURISDICTION   JURISDICTION
                                                  TOTAL                 I              II             III
     ****************************************   **********         **********     **********     **********

     TOTAL POPULATION                              275500             126000         149500              0
                              LOW    CLASS          73500                  0          73500              0
                              MIDDLE CLASS          99000              64000          35000              0
                              HIGH   CLASS         103000              62000          41000              0


     PERCENT CHANGE OVER PREVIOUS YEAR                  0
     AVERAGE POPULATION PER PARCEL                      0                  0              0              0

     DEVELOPED LAND (IN PARCELS)                       77                 30             46              0
     UNDEVELOPED LAND                                 548                266            283              0
     TOTAL LAND AREA                                  625                296            329              0

     ASSESSED VALUE OF LAND                        12312.              5321.          6992.             0.
         IN MILLIONS

     ASSESSED VALUE OF DEVELOPMENTS                  421.               158.           264.             0.
         IN MILLIONS
     AVERAGE QUALITY OF LIFE INDEX                     69                 61             75              0
     NUMBER OF REGISTERED VOTERS                    88573              45566          43007              0
     NO. IN PUBLIC ADULT EDUCATION                      0                  0              0              0

     AVERAGE EDUCATIONAL LEVEL                         59                 73             47              0
         LOW                                           17                  0             17              0
         MIDDLE                                        61                 61             62              0
         HIGH                                     5232824            4061270         278305              0


     NO. OF WORKERS RECEIVING WELFARE               12800                  0          12800              0

     STUDENT/TEACHER RATIO                              7                 13             10              0

     SCHOOL ENROLLMENT
         PUBLIC                                     48740              34040          14700              0
         PRIVATE                                    20460                  0          20460              0

     HOUSING UNITS
         SINGLE    DWELLINGS                          100                 62             38              0
         MULTIPLE  DWELLINGS                           24                  7             17              0
         HIGH RISE APARTMENTS                           6                  4              2              0

     VACANCY RATE         (PERCENT)                     4                 28            -23              0
         NEGATIVE MEANS OVERCROWDED
```

Figure - 9.1 (Cont'd)

```
NUMBER OF EMPLOYED WORKERS                   79400              35360       44040         0
     LOW                                     23000                  0       23000         0
     MIDDLE                                  31680              20480       11200         0
     HIGH                                    24720              14880        9840         0


NUMBER EMPLOYED IN
     LIGHT     INDUSTRY                      27160              10240       16920         0
     HEAVY     INDUSTRY                      27760              11800       15960         0
     NATIONAL  SERVICES                          0                  0           0         0
     CONSTRUCTION INDUSTRY                       0                  0           0         0
     BUSINESS  GOODS                          2800               1680        1120         0
     BUSINESS  SERVICES                       5240                  0        5240         0
     PERSONAL  GOODS                          3360               3360           0         0
     PERSONAL  SERVICES                       5680               2480        3200         0
     MUNICIPAL SERVICES                       1920               1920           0         0
     SCHOOLS                                  3880               3880           0         0
     RAIL                                        0                  0           0         0
     BUS                                         0                  0           0         0
     FEDERAL-STATE                            1600                  0        1600         0

NUMBER OF UNEMPLOYED WORKERS                  6400                  0        6400         0
     LOW                                      6400                  0        6400         0
     MIDDLE                                      0                  0           0         0
     HIGH                                        0                  0           0         0


UNEMPLOYMENT RATE    (PERCENT)                7.46               0.0        12.69      0.0
     LOW                                     21.77               0.0        21.77      0.0
     MIDDLE                                  0.0                 0.0        0.0        0.0
     HIGH                                    0.0                 0.0        0.0        0.0

PERCENT EARNING      UNDER $ 5,000              33                  5          55         0
PERCENT EARNING $5,000 TO $10,000               37                 54          22         0
PERCENT EARNING       OVER $10,000              29                 39          21         0
```

Number in public adult education: the number of people who wanted to participate in public adult education programs and were able to do so because programs were provided by their school departments.

Average educational level: by class, the average educational level. This ranges from 0 to 100. The higher a worker's educational level relative to those of other workers, the greater his chances of being hired before the others.

Number of workers receiving welfare: if a jurisdiction does have a program for aid to the unemployed, this number is the number of unemployed workers. The number is zero if there are either no unemployed workers or no welfare program.

Student/teacher ratio: ratio of number of students attending local public schools to number of teachers employed by public schools. This is a factor when students are allocated to public or private schools.

School enrollment: the number of students attending local public schools and the number attending private schools. Students attend private schools only if the public schools in their districts are inadequate.

Housing units: the number of levels of RA (single family), RB (town house, multiple dwellings), and RC (high rise) housing.

Vacancy rate: the ratio of existing housing space to housing space occupied, expressed as a percent. A negative rate means that housing is overcrowded.

Number of employed workers: the number of people holding full-time jobs, by class of worker.

Number employed by type of employer: the number of full-time workers employed by each type of business and government employer.

Number of unemployed workers: by class, the number of workers seeking full-time employment who were unable to obtain jobs.

Unemployment rate (percent): by class, the number of unemployed workers as a percent of the total number of workers who sought full-time jobs.

Earning distribution: the percent of workers earning less than $5,000, between $5,000 and $10,000, and over $10,000 from full-time employment.

Transactions With the National Economy

Income from the national economy: federal-state aid received, by type of aid, and income from both basic industry sales of output and bus and rail sales of equipment.

Sales to the national economy: federal-state taxes paid, by type of tax, and purchases of goods, services, and outside-owned land. The only Outside expenditure which can be significantly controlled locally is the purchase of goods and services due to local insufficiency.

National economy business cycle: last round's ratio to "typical income"per unit of output for basic industry, interest rates on loans and bonds from the Outside (expressed as percents), and the average rate of return on outside investments (expressed as percents).

2. Summary Information for the Social Sector

Social Control Summary

This table shows, by class and jurisdiction, the number of population units controlled by each social decision-maker. A social decision-maker begins a game controlling a certain number of Pl's in each class in each jurisdiction (that number may be zero). The number of Pl's which the decision-maker controls in subsequent rounds is determined by the migration process, which moves Pl's into, out of, and within the simulated region in response to both local and exogenous influences. The migration process allocates people to housing; it does not determine which social decision-makers control those people. Before the start of a game, each parcel in the simulated region is assigned a decision-maker for each of the three social classes. When a class occupies a parcel, it comes under the control of the decision-maker originally assigned to that class on that parcel. The Social Decision-Maker Map shows which teams control classes already living on residence parcels. When a new class occupies a parcel, its decision-maker appears on the map.

Social Control Summary (one table for each social decision-maker)

Figure 7.5

```
****************************************************
           TWOCITY
     SOCIAL CONTROL SUMMARY TOTALS        ROUND  2
****************************************************


             JURISDICTION 1       JURISDICTION 2


     TEAM        PH    PM    PL        PH    PM    PL


      AA          0    94     0         0     0     0

      BB         43     0     0         0     0     3

      CC          0    20     0        25     0     0

      DD          0     0     1         0     3   153

      EE         48     2     0        14     1     0

      FF          0     0     2         0    67     0

      GG         36     0     0        42    10     0
```

Figure 7.4

```
**********************************************************************
          TWOCITY
      SOCIAL CONTROL SUMMARY TEAM AA                          ROUND  2
**********************************************************************

                      FAMILY INCOME                          TOTAL
LOCATION     CLASS    (PER WORKER)    FAMILY SAVINGS    DISSATISFACTION

  8828      MIDDLE        5071              -495              353

  9028      MIDDLE        2500             -2006              292

  8830      MIDDLE        6180               503              353

  9030      MIDDLE        4753                70              327

  8832      MIDDLE        2800             -2137              441

  9032      MIDDLE        4798               122              415

  9232      MIDDLE        3625             -1235              457

  9034      MIDDLE        4458              2228              367

  9234      MIDDLE        2662              -764              355
```

This table contains one row for each class on each parcel controlled by the social decision-maker. The first two columns show the residence parcel coordinates and the class. Next is the average income for a household (family) of that class living on that parcel. A household consists of one full-time worker. The number of workers in a Pl of each class and the typical full-time salary earned by a worker in the class are shown on the Master Tables. In almost all of the model's processes, all Pl's in the same class living on the same parcel are treated alike, so the average for a parcel is in effect the actual for a Pl.

The fourth column contains the average savings per family for the year. The figure is annual income less annual expenditures, and does not include any savings or dissavings from previous years.

The final column, total dissatisfaction, is the total of all of the indexes measuring the effect of local conditions on the population on the parcel. The higher the dissatisfaction, the worse the conditions. The dissatisfaction index is the quality of life index, which is a factor in the migration process.

Social Control Summary (two graphs for each social decision-maker)

The two graphs printed for each social decision-maker show an historical comparison of two types of information shown on the previously-described table: net income and quality of life index. Whereas on the tables information is given for each class on each parcel which the decision-maker controls, the information on the graphs is the average of all of the Pl's in the same class controlled by the decision-maker. The graphs show the relative values of those items for the most recent ten years. Each year has three columns on the graph, one for low-income (L), one for middle-income (M), and one for high-income (H). Round 1 is Year 5 on the graph, Round 2 is Year 6, and so on. After 6 rounds have been played (years 5 through 10 on the graph), the data for the earliest year are erased and only data for the most current 10 years are shown. Year 10 is always the most recent round.

On the net income graph, the net income for each class for each year is shown as a ratio to that class's net income during the first year. The first year is always 1.00. Thus, although high-income Pl's usually have a higher net income than middle-income Pl's, their incomes

Figure 7.7a

Social Graphs for Teams: Relative Per Capita
Income by Class

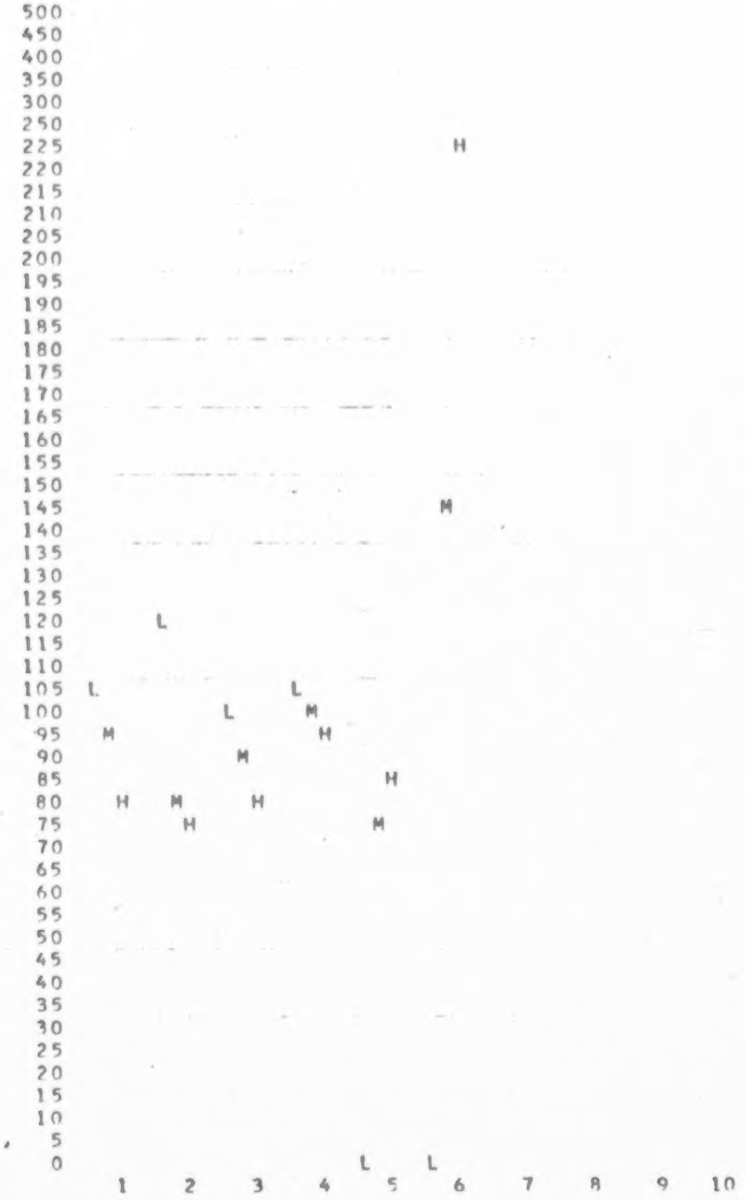
```
*************************************************************
                                TWOCITY
                          SOCIAL CONTROL SUMMARY TEAM GG
*************************************************************

                        - NET INCOME -

     3.00
     2.00
     1.90
     1.80
     1.70
     1.60
     1.55
     1.52
     1.50
     1.48
     1.45
     1.42
     1.40
     1.38
     1.35
     1.33
     1.30
     1.28
     1.25
     1.23
     1.20
     1.18
     1.15                        H
     1.12
     1.10
     1.08                             H
     1.05            L    L
BASE 1.03       L           H
 --  1.00  LMH   MH   MH   M
YEAR 0.98
     0.95
     0.93
     0.90                       M
     0.88
     0.85
     0.83                            M
     0.80
     0.75
     0.70
     0.65
     0.60
     0.55
     0.50
     0.45
     0.40
     0.35
     0.30
     0.25
     0.20
     0.15
     0.10
     0.0                       L    L
     YEAR   1    2    3    4    5    6    7    8    9   10
```

Figure 7.7b

Social Graph for Teams: Quality of Life Index by Class

ROUND 2

- QUALITY OF LIFE INDEX -



relative to previous years can be easily compared even across classes.

If a decision-maker does not control any PI's in a particular class during a year, that class's letter prints on the bottom row of the graph.

The quality of life index graph shows each class's average quality of life index as an absolute value, not relative to a base year. Each class measures the factors in the quality of life index differently, so there can be little comparison between classes on this graph. The main comparison is within a class between years.

3. Summary Information for the Economic Sector

Number of Levels of Economic Activity Owned by Teams

The table contains one row per economic team and one column for each type of economic activity. Each entry in the table is the number of levels of an activity controlled by an economic team in the simulated region. The last column, UN, is the number of undeveloped parcels which the team owns. The table provides a simple summary of how economic decision authority is currently distributed. It may be observed whether certain teams are specializing or not, whether certain types of businesses exist at all in the region, and in general, how much economic activity is going on.

Economic Control Summary (one table per economic decision-maker)

This table provides a simplified picture of the status of each business and residence controlled by the team. There is one row per economic activity. The first two columns show the coordinates and type and level of the activity.

The third column is the production idex, if the activity is a business, or the occupancy rate, if the activity is a residence. A residence's occupancy is expressed as a percent of its capacity. A residence can be occupied by to 120% of its capacity. The greater the occupancy, the more income earned by the owner from rents. A business's production index is a measure of its actual output or capacity as a percent of its maximum output or capacity. In the case of a basic industry, the index is the number of units it actually produced as a percent of its design capacity. The production index of a commercial

Figure 7.1

```
************************************************************************************************************************************
                                TWOCITY
                           NUMBER OF LEVELS OF ECONOMIC ACTIVITY OWNED BY TEAMS                                           ROUND  2
************************************************************************************************************************************

TEAM   FL    SG    MP    MF    NL    EL    TE    FO    TA    PA    CR    NS    BG    BS    PG    PS    CI    RA    RB    RC    UN
----  ----  ----  ----  ----  ----  ----  ----  ----  ----  ----  ----  ----  ----  ----  ----  ----  ----  ----  ----  ----  ----

 A     0     0     1     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     11
                   -                                                                                                           --
 B     0     0     0     0     0     0     0     0     0     0     0     0     0     1     0     1     0     11    3     1     5
                                                                                     -           -           --    -     -     -
 C     0     0     0     0     0     0     0     0     0     0     0     0     1     0     0     0     0     10    4     1     5
                                                                               -                             --    -     -     -
 D     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     25    7     2     3
                                                                                                             --    -     -     -
 E     0     0     0     0     0     0     0     0     0     0     0     0     0     0     1     0     0     19    1     1     3
                                                                                           -                 --    -     -     -
 F     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     29    7     1     4
                                                                                                             --    -     -     -
 G     0     0     0     0     0     0     1     1     0     1     0     0     0     0     0     0     0     6     2     0     4
                                           -     -           -                                               -     -           -
```

Figure - 7.3

```
**********************************************************************
         TWOCITY
    ECONOMIC CONTROL SUMMARY   TEAM G                      ROUND  2
**********************************************************************


                            PRODUCTION INDEX                          RATE
   PARCEL                         OR                                   OF
  LOCATION     ACTIVITY     OCCUPANCY RATE          NET INCOME       RETURN


    9822         RA 2            100                  282496          19.28%

   10224         RA 4            117                  764963          23.91%

   10026         RB 2            117                 -135668          -1.67%

    9828         TE 1            100                23406766          13.00%

    9630         PA 1             96                77502504          32.29%

    9432         FO 1            100                68745011          29.89%
```

establishment is its effective capacity (the amount which it can adequately serve) to its design capacity. A production index of 100 is the highest which a business can have.

The fourth column, net income, is a business's total income from sales or a residence's total income from rents, less operating expenditures.

The last column, rate of return, is perhaps the most information single indicator of an activity's status. Rate of return is the net income as a percent of the development cost, and if a business is doing reasonably well, it usually averages around 10-25%. A decision-maker may use rates of return as guides for deciding which activities to focus his attention on.

Further detail on rate of return is contained in the section describing Economic Detailed Output.

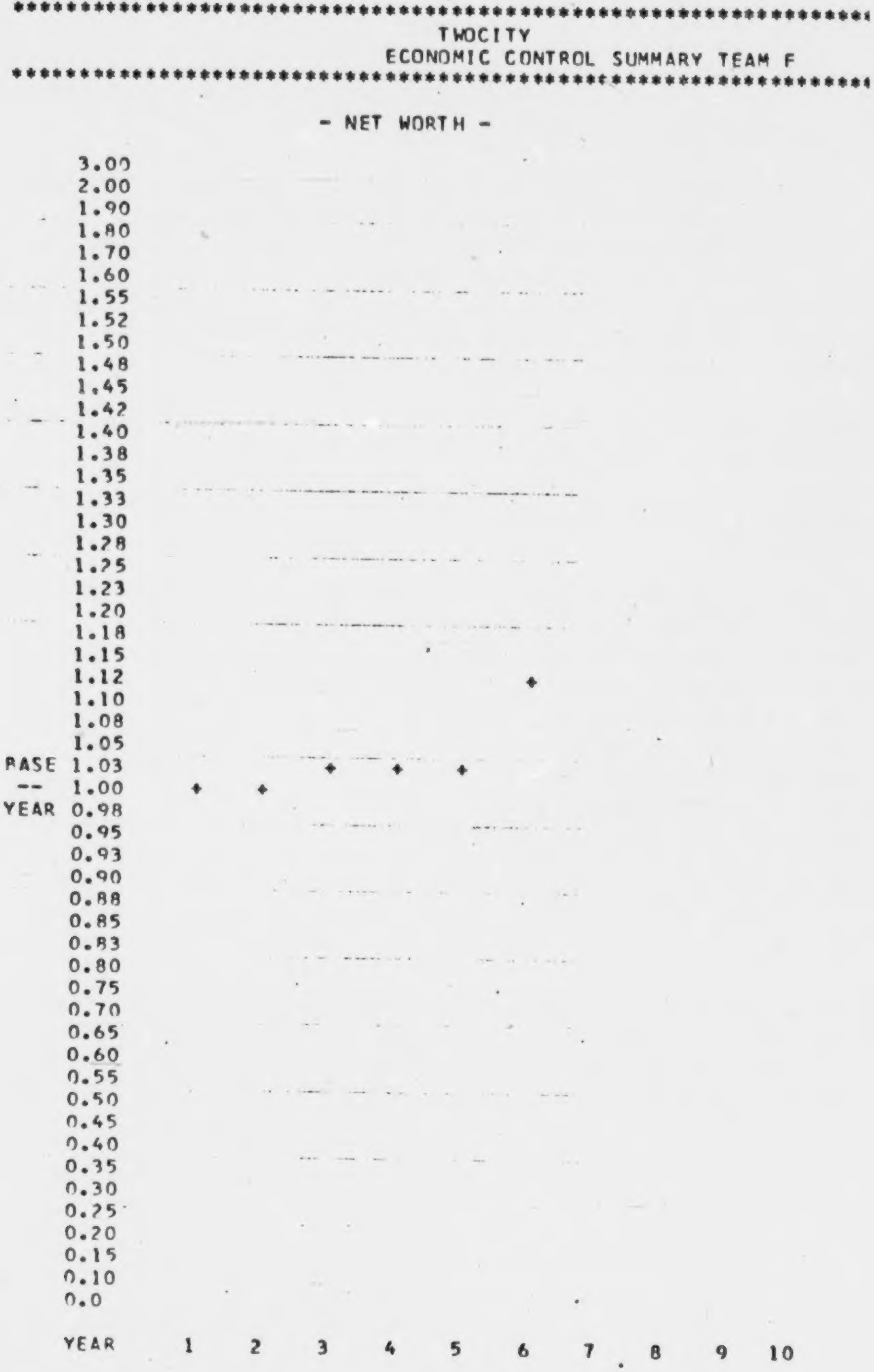
Economic Control Summary (two graphs per economic decision-maker)

The two graphs printed for each economic decision-maker show an historical comparison of two types of information: net worth and rate of return. Whereas net worth is the team's total net worth (assets less liabilities), the information on rate of return is the average rate of return of all of the activities controlled by the team. The graphs show the relative values of those items for the most recent ten years. Round 1 is Year 5 on the graph, Round 2 is Year 6, and so on. After 6 rounds have been played (years 5 through 10 on the graph), the date for the earliest year are erased and only data for the most current 10 years are shown. Year 10 is always the most recent round.

On the net worth graph, the team's net worth for each year is shown as a ratio to its net worth in the first year. The first year is always 1.00. The second graph shows the team's average rate of return as an absolute percent, not relative to a base year.

Figure 7.6a

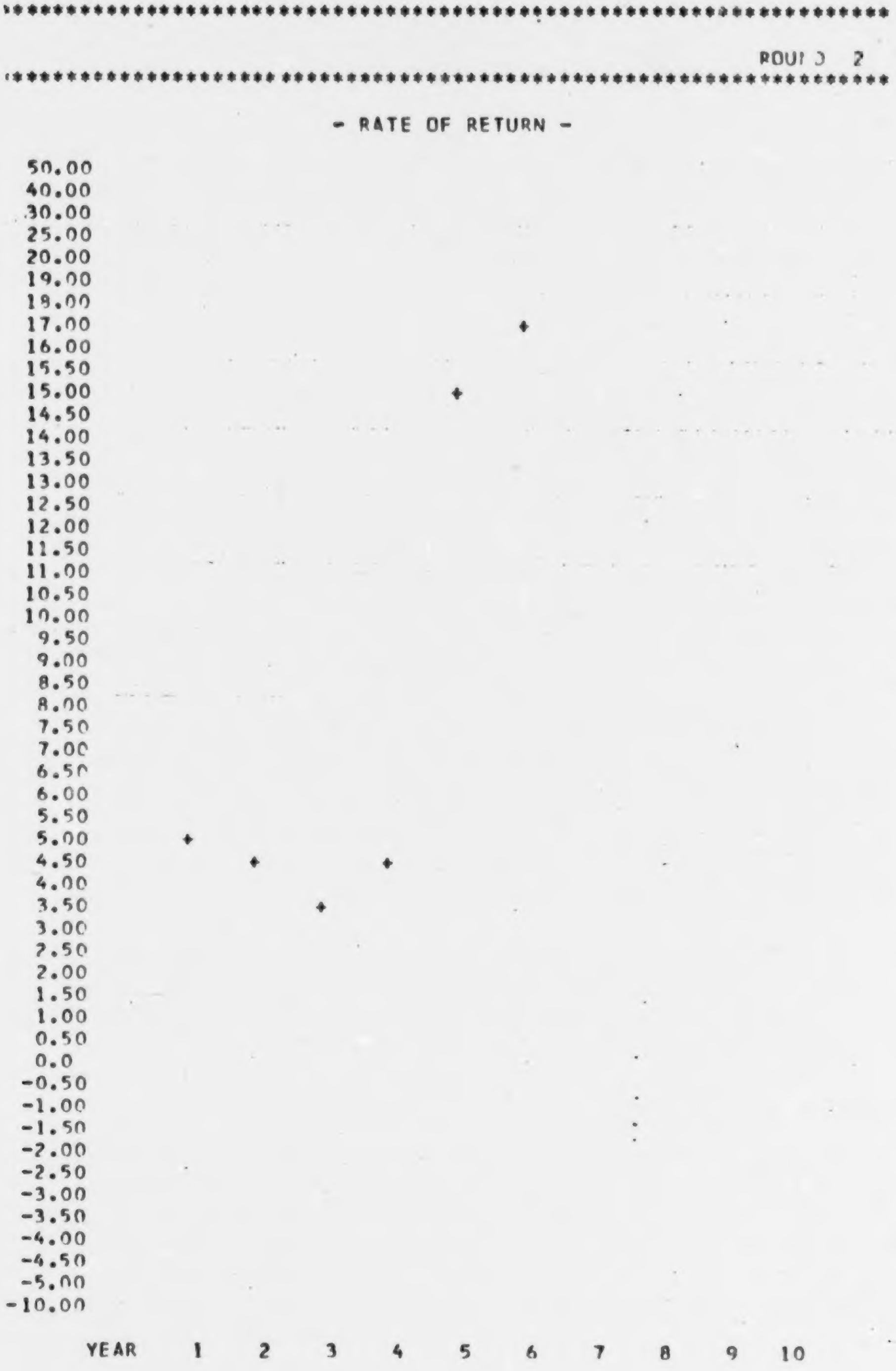
Economic Graphs for Teams: Net Worth



```
*****************************************************************
                                 TWOCITY
                           ECONOMIC CONTROL SUMMARY TEAM F
*****************************************************************

                    - NET WORTH -

       3.00
       2.00
       1.90
       1.80
       1.70
       1.60
       1.55
       1.52
       1.50
       1.48
       1.45
       1.42
       1.40
       1.38
       1.35
       1.33
       1.30
       1.28
       1.25
       1.23
       1.20
       1.18
       1.15
       1.12                                  +
       1.10
       1.08
       1.05
  BASE 1.03             +     +     +
   --  1.00     +    +
  YEAR 0.98
       0.95
       0.93
       0.90
       0.88
       0.85
       0.83
       0.80
       0.75
       0.70
       0.65
       0.60
       0.55
       0.50
       0.45
       0.40
       0.35
       0.30
       0.25
       0.20
       0.15
       0.10
       0.0

       YEAR     1    2    3    4    5    6    7    8    9    10
```

Figure 7.6b

Economic Graphs for Teams: Rate of Return



D. General Information

1. MIGRATION OUTPUT

The first major computer process in each round is migration. The program moves population units within, into, and out of the simulated region in response to both local conditions and exogenous influences. The selection of which population units move each year and where they choose housing is entirely controlled by the computer program, although player decisions greatly affect the process.

Most of the local conditions which influence migration are expressed as indexes which are summed into the two basic indexes used in migration: environmental indexes (measures of neighborhood quality) and personal indexes (measures of personal dissatisfaction). The higher an index is, the worse the quality; a low index indicates better quality.

Indexes are relative, never being compared to a norm or even across classes. For example, each residence parcel has three environmental indexes, one for each class. Environmental indexes are used alone (i.e., with no other indexes added to them) only in the selection of housing. Local housing is rated for selection by movers in order of environmental indexes, with the lowest index first and the highest last. If there were a great demand for housing, even the worst residences would be chosen by movers. If there were an excess of housing, only those residences having the lowest environmental indexes would be chosen by movers.

The sum of a parcel's environmental index and the personal index of a class living there is that population group's quality of life index. The quality of life index is used to determine which population units leave their housing to find better places to live. A random half of the 20% of the population units with the highest quality of life indexes within each class leave their housing.

All of the indexes are calculated before any people move. The migration output shows in detail the value of each factor in each index, and how many population units moved where and for what reason.

Environmental Indexes

This section of output prints the value of each factor in the environmental index for each residence parcel for each class. The parcels are listed according to where they are located on the board, the order being from left to right and top row to bottom row. The first column of this output contains the coordinates of the residence parcel for which

COMPONENTS OF THE QUALITY OF LIFE INDEX

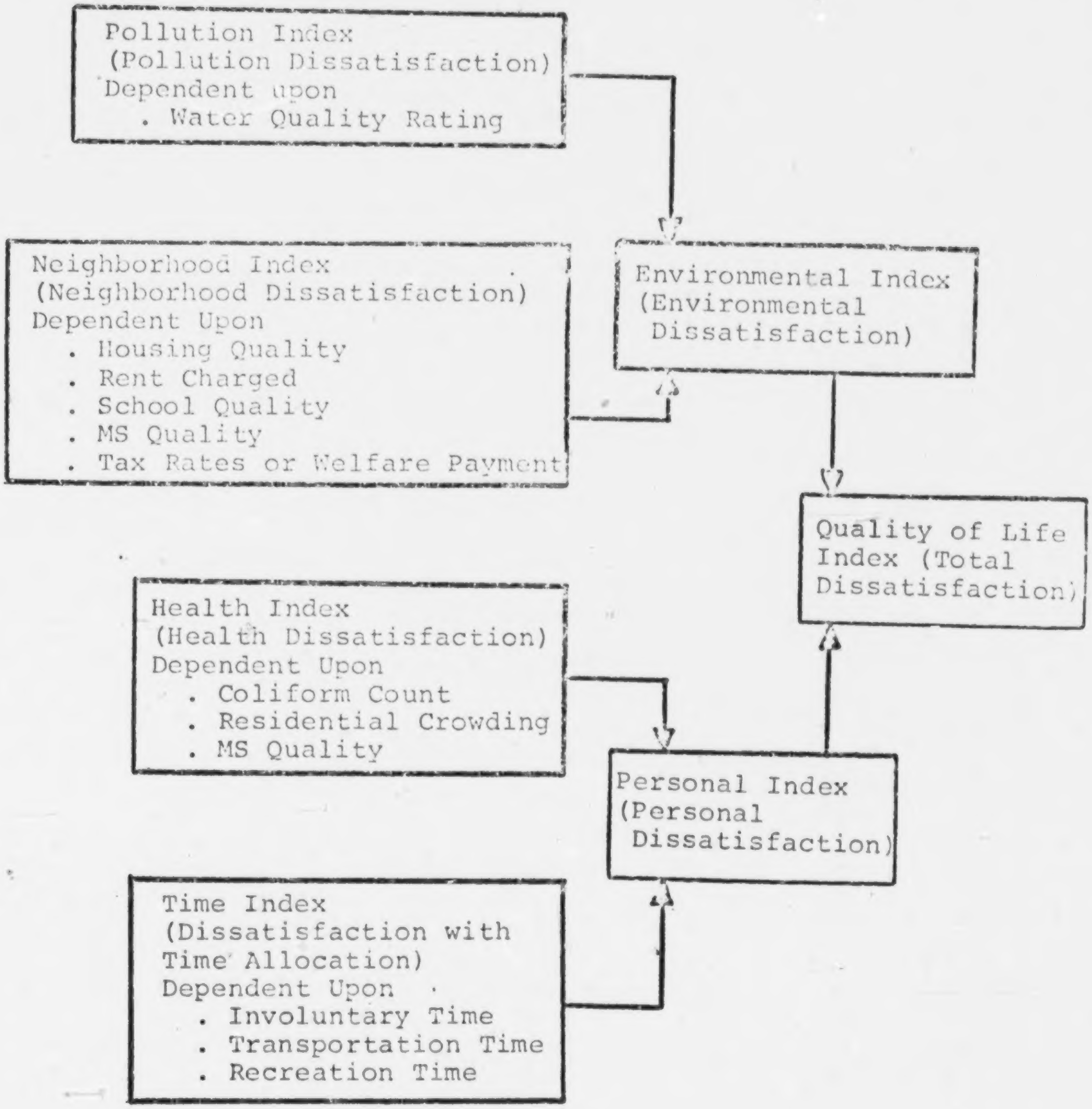

Pollution Index
(Pollution Dissatisfaction)
Dependent upon
. Water Quality Rating
Neighborhood Index
(Neighborhood Dissatisfaction)
Dependent Upon
. Housing Quality
. Rent Charged
. School Quality
. MS Quality
. Tax Rates or Welfare Payment
Environmental Index
(Environmental
Dissatisfaction)
Quality of Life
Index (Total
Dissatisfaction)
Health Index
(Health Dissatisfaction)
Dependent Upon
. Coliform Count
. Residential Crowding
. MS Quality
Personal Index
(Personal
Dissatisfaction)
Time Index
(Dissatisfaction with
Time Allocation)
Dependent Upon
. Involuntary Time
. Transportation Time
. Recreation Time

Figure 1.1

```
**************************************************************************************************************
          TWOCITY
     ENVIRONMENTAL INDEXES
**************************************************************************************************************
                                                                                                       ROUND  2
**************************************************************************************************************

                                          NEIGHBORHOOD INDEX
                            ---------------------------------------------------------
 LOCATION   POLLUTION             RESIDENCE                            WELFARE                  ENVIRONMENTAL
              INDEX      CLASS     QUALITY    RENT  MS  SCHOOL  OR TAXES  TOTAL               INDEX
 --------   ---------    -----    ---------   ----  --  ------  --------  -----           ------------

   9422        -7        LOW          19        0  100     0        12      131                124
                         MIDDLE       39        0  100     0        24      163                156
                         HIGH         49        0  100     0        24      173                166

   9622       -15        LOW          44        0  100     0        16      160                145
                         MIDDLE       64        0  100     0        18      182                167
                         HIGH         74        0  100     0        18      192                177

   9822        -7        LOW          19        0  100     0        16      135                128
                         MIDDLE       39        0  100     0        18      157                150
                         HIGH         49        0  100     0        18      167                160

  10022         0        LOW          14        3  100     0        16      133                133
                         MIDDLE       34        0  100     0        18      152                152
                         HIGH         44        0  100     0        18      162                162

   9424        -7        LOW          35        0  100     0        12      147                140
                         MIDDLE       55        0  100     0        24      179                172
                         HIGH         65        0  100     0        24      189                182

   9624       -15        LOW          40        0  100     0        16      156                141
                         MIDDLE       60        0  100     0        18      178                163
                         HIGH         70        0  100     0        18      188                173

   9824        -7        LOW          40        0  100     0        16      156                149
                         MIDDLE       60        0  100     0        18      178                171
                         HIGH         70        0  100     0        18      188                181

  10024         0        LOW          35        0  100     0        16      151                151
                         MIDDLE       55        0  100     0        18      173                173
                         HIGH         65        0  100     0        18      183                183

  10224         0        LOW          10       69  100     0        16      195                195
                         MIDDLE       30       16  100     0        18      164                164
                         HIGH         40        0  100     0        18      158                158

   8826         0        LOW           0       78  100     0        12      190                190
                         MIDDLE        9       22  100     0        24      155                155
                         HIGH         19        1  100     0        24      144                144
```

the rest of the information in the row applies. There are three rows of information printed for each residence parcel, one row per class. The different classes weigh some of the factors in the environmental index differently.

The environmental index is the sum of the pollution index and the neighborhood index. The pollution index is derived from the surface water quality on a residence parcel or, if the parcel does not contain surface water, from the quality on bordering parcels. This index is the only factor in the environmental index which can be negative; good local water quality adds to a residence parcel's attractiveness. The index has the same value for all three classes.

The neighborhood index is the sum of several indexes: residence quality, rent, municipal service quality, school quality, local tax rates, and local welfare rates.

RESIDENCE QUALITY: A residence owner determines the residence's initial quality index and its maintenance level. Residences, unlike all other constructions, can be built at a quality less than 100. A residence quality index of 50 does not mean that the residence is half falling down; it does mean that the residence was either built more cheaply than residences with higher quality indexes or not maintained at a higher quality. The quality index is rated differently by the different classes, since low-income population units are not quite as demanding of highest quality as high-income are. To derive the value of this factor, the residence's quality index is subtracted from 100 for high-income, from 90 for middle-income, and from 70 for low income. The higher a residence's quality index, the less value this factor has.

RENT: A residence owner also sets the rent charged at the residence. The different classes evaluate a residence's rent differently. The simulated region has a "typical" rent for each class (see the Master Tables for their exact values). The typical rent is subtracted from the residence's rent and multiplied by a weighting factor. The weight for high-income is 1, for middle-income 2, and for low-income 3. Thus, a low-income group puts a greater weight on rent deviation from its typical than high-income does.

MS: The Municipal Services Department constructs and operates MS units. The quality of a municipal service unit is measured as the MS use index. An MS use index can range in value from 0 to 200. An index of 100 indicates most efficient service. An index less than 100 indicates adequate but underused capacity and an index over 100 indicates overuse of services. For the nieghborhood index, 100 points are subtracted from the use index of the MS unit serving the MS district in which a residence parcel is located. If the use index is 100 or less, the factor in the neighborhood index is zero. Only a use index over 100 contributes to the neighborhood index.

SCHOOL: The School Department constructs and operates school units. School quality is also measured as a use index. Again, 100 points are subtracted from the use index of the school serving the school district in which a residence parcel is located. Only a school use index over 100 contributes to the neighborhood index.

WELFARE OR TAXES: Both welfare rates and tax rates are set by a Chairman for a whole jurisdiction, so these factors contribute to which jurisdiction a population unit selects housing in. All of the other factors in the neighborhood index are more localized, affected by conditions on individual residential parcels or individual school or MS districts.

Low-income population units consider only the former of these two local government policies. For the neighborhood index for low-income, 1 point is added for each $25 which the welfare payment per unemployed worker is less than $2000. Middle and high-income groups consider only local tax rates. For the neighborhood index, one-fourth point is added for each tenth of a percent resident income, goods, and services tax rate and one-eighth of a point is added for each mil land and developments tax rate.

The last column of this output is the total environmental index, the sum of the pollution index and the neighborhood index.

Personal Indexes

This output prints, for each class living on each parcel, the value of each factor in the personal index. Unlike environmental indexes, personal indexes are calculated only for classes already living on residence parcels. A population group's personal index is added to the environmental index for its class on its residence parcel, resulting in its quality of life index, the relative value of which affects whether the population units will move.

A class's health index is the sum of the values derived from three sources: municipal service quality, residential crowding, and the amount of coliform bacteria in the nearby surface water. The maximum value of the health index is 100.

Figure 1.2

```
************************************************************************************************************************
          TWOCITY
      PERSONAL INDEXES                                                                                         ROUND  2
************************************************************************************************************************

                       HEALTH INDEX
           ------------------------------------
                         CROWDING  BACTERIA                   TRANSP.          INVOL.    PERSONAL
LOCATION    MS EFFECT     EFFECT    EFFECT    TOTAL   CLASS     TIME    RECR.   TIME       INDEX
--------   ----------   --------  --------   -----   -----   -------   -----  ------    --------

  9422          25          25         0       50  -  LOW          0       0      0         50
                                                      MIDDLE      25      10     72        137
                                                      HIGH         0       0      0         50

  9622          25           0         0       25    LOW         25       3     80        127

  9822          25           0         0       25    LOW         65       3     72        159

 10022          25           0         0       25    LOW        105       3     64        191

  9424          25           0         0       25    MIDDLE      15      10     77        107

  9624          25          21         0       46    LOW         75       3     77        195

  9824          25           0         0       25    LOW          0       3     95        117

 10024          25          25         0       50    LOW        140       3     60        247

 10224          25           0         0       25    LOW        105       3     74        201

  8826          25           0         0       25    MIDDLE      75      10     65        155

  9026          25           0         0       25    MIDDLE      15      10     77        107

  9226          25          25         0       50    MIDDLE      15      10     74        129

  9426          25          25         0       50    MIDDLE      25      10     82        147

 10026          25          25         0       50    LOW         85       3     73        205

 10226          25          21         0       46    LOW         95       3     64        202

 10826           0           0         0        0

  8628          25           0         0       25    HIGH       175      10     35        225
```

MS EFFECT: The value of the MS factor in the environmental index is divided by four for its value in the health index.

CROWDING EFFECT: A residence can be occupied up to 120% of its constructed capacity. For each percent which it is overcrowded (over 100% occupied) 1.2 points are added to the health index.

BACTERIA EFFECT: The concentration of coliform bacteria in the surface water on a parcel affects the health index of that parcel and adjoining parcels. A parcel adjoins a surface water parcel if any of its corners touches a surface water parcel's corner. The coliform count on a parcel which adjoins a surface water parcel is the highest count of all of the surface water parcels which it adjoins. When used in a parcel's health index, the coliform count is divided by 4 and can have a maximum value of 50 points.

The other factors in the personal index reflect a class's time allocation and quality of public recreation facilities.

TRANSPORTATION TIME: The time spent traveling to work is averaged for a class on a parcel for the purposes of allocating the rest of their time. Work is the only activity which population units in the same class living on the same parcel do not perform as a group. Thus, each population unit could be working at a different employment location and spending a different amount of time getting there. For each average time unit spent in transportation to work in the previous round, five points are added to the personal index.

RECREATION: Social decision-makers allocate time to recreation, and that time is subtracted from the personal index. However, the sufficiency of local parks affects the number of points which are subtracted. Park adequacy is measured in a use index like school and MS adequacy. If the use index of the most overused park within a two-parcel radius is over 100, the percent of the points subtracted from the personal index due to recreation is decreased. The number printed here is the number of points subtracted after recreation time has been adjusted for the park use index.

INVOLUNTARY TIME: The time which a social decision-maker allocated to various activities and which the population units were unable to spend in those activities is involuntary allocation of time. For example, if the decision-maker allocated 25 time units to extra work and, due to a limited number of part-time jobs, the population units were only able to spend 10 time units in part-time work, 15 points would be added to involuntary time.

Dissatisfaction Cutoffs

A random half of the 20% of the population units in the simulated region having the highest personal indexes are selected to seek better housing (housing with a lower environmental index than their current housing). The top row of this output shows, by class, the personal index value below which 80% of the population falls and above which 20% of the population falls. A population unit with a personal index above the relevant dissatisfaction cutoff has a 50-50 chance of being selected for moving due to dissatisfaction.

The rest of this output has one row per jurisdiction and one column per class showing the number of Pl's of the class initially in the jurisdiction. The top row is jurisdiction one and the bottom row is jurisdiction three.

Migration Detail

There are reasons other than dissatisfaction for which a population unit might move out of its housing. A fixed percentage of all unemployed and underemployed population units automatically leave their housing and move to the Outside system, i.e., they leave the simulated region and disappear. In addition, population units may leave overcrowded housing (housing over 120% occupied), usually due to partial or total residential demolition. Those displaced Pl's seek local housing and leave the system only if they are unable to find acceptable housing.* Another fixed percentage of each class's population units are chosen randomly to seek better housing. These Pl's, together with the Pl's seeking housing because they were the most dissatisfied, leave the system if they cannot find acceptable housing with a neighborhood index below that of their previous housing.

Besides local movers, a percent of the local population in each class comes from the Outside to seek housing. This group represents natural population growth. Another group of Pl's seeks local housing in response to local employment opportunities. These two types of movers leave the local system only if they cannot find acceptable housing.

The migration detail output shows, for each residence parcel, the residence owner, the social decision-maker controlling each class living there after the migration process has run, the number of Pl's in each class living there after the migration process, the quality of life index for that class (this prints zero if the class was not living on the parcel in the previous round), the number of Pl's who moved to or from the parcel during the migration process, where they came from or went to, their reason for moving and the location of their employer.

---

*Acceptable housing is housing with a quality index ranging from 20 to 70 for low, 40 to 100 for middle, and 71 to 100 for high.

Figure 1.3

```
         DISSATISFACTION CUTOFFS

     LOW       MIDDLE      HIGH
     396        441        482

       0        128        124        252

     147         70         82        299

       0          0          0          0

     147        198        206        551
```

Figure 1.4

```
*****************************************************************************************************
                 TWOCITY
            MIGRATION DETAIL                                                                ROUND  2
*****************************************************************************************************

                     SOCIAL   NUMBER
                    DECISION    OF                QUALITY OF   NUMBER                FROM/TO     REASON FOR
PARCEL OWNER TYPE    MAKER     PI'S     CLASS        LIFE       MOVED                PARCEL        MOVING          EMPLOYER
------ ----- ----  --------  ------   -----     ----------   ------                -------   --------------     --------

 9422    B   RA 1      F          1   LOW           174           1  CAME FROM        0      IN-MIGRATION             0

                       C          1   MIDDLE        293           1  WENT TO      10224      DISPLACEMENT          9626

 9622    D   RA 1      D          2   LOW           272

 9822    G   RA 2      D          4   LOW           287           1  CAME FROM        0      IN-MIGRATION             0

10022    F   RA 4      D          9   LOW           324           2  CAME FROM        0      IN-MIGRATION             0

 9424    C   RA 1      F          1   LOW             0           1  CAME FROM    10224      DISSATISFACTION       9828

                       C          1   MIDDLE        279

 9624    F   RB 2      D         28   LOW           336

 9824    C   RB 3      D         44   LOW           266           4  WENT TO          0      UNEMPLOYMENT             0
                                                                  3  CAME FROM        0      IN-MIGRATION             0
                                                                  1  CAME FROM    10026      DISPLACEMENT          9632
                                                                  1  CAME FROM    10030      DISPLACEMENT          9928
                                                                  1  CAME FROM    10224      DISSATISFACTION       9626
                                                                 10  CAME FROM    10024      DISSATISFACTION       9630

10024    C   RB 1      D         14   LOW           398          10  WENT TO       9824      DISSATISFACTION       9630
                                                                  6  CAME FROM        0      IN-MIGRATION             0

10224    G   RA 4      D          4   LOW           396           1  WENT TO       9824      DISSATISFACTION       9626
                                                                  1  WENT TO       9424      DISSATISFACTION       9828
                                                                  1  WENT TO      10232      DISSATISFACTION       9832
```

When the location given for origin or destination of a group is zero, the group came from or went to the Outside system. New in-migrants or natural growth migrants always have employment locations of 0. Of these two types of movers, any who cannot find acceptable local housing are not shown on this output.

Migration Statistics

This output is a summary which shows, by class and jurisdiction, the original population, the number of in-migrants from the Outside system, the inmigration from other jurisdictions, the in-migration due to natural population growth, the outmigration to the Outside system, the outmigration to other jurisdictions, the migration totally within each jurisdiction, and the final population. All numbers are expressed in Pl's.

Migration By Type

This summary output shows, by class and by jurisdiction, the number of Pl's who moved for each reason from each jurisdiction (including Outside) to each other jurisdiction. Shown here is the total number of Pl's from the Outside who remained Outside due to local housing insufficiency. They are indicated as having come from Outside and gone to Outside.

Figure 1.5

MIGRATION STATISTICS

```
ORIGINAL POPULATION
JURIS           PL              PM              PH
  1              0             128             124
  2            147              70              82
  3              0               0               0

IN-MIGRATION FROM OUTSIDE SYSTEM
JURIS           PL              PM              PH
  1              2               1               0
  2             13               1               2
  3              0               0               0

IN-MIGRATION FROM OTHER JURISDICTIONS
JURIS           PL              PM              PH
  1              1               2               3
  2              0              12               1
  3              0               0               0

NATURAL POPULATION GROWTH
JURIS           PL              PM              PH
  1              0               0               3
  2              2               3               0
  3              0               0               0

OUT-MIGRATION TO OUTSIDE SYSTEM
JURIS           PL              PM              PH
  1              0               3               2
  2              5               3               1
  3              0               0               0

OUT-MIGRATION TO OTHER JURISDICTIONS
JURIS           PL              PM              PH
  1              0              12               1
  2              1               2               3
  3              0               0               0

MIGRATION WITHIN JURISDICTIONS
JURIS           PL              PM              PH
  1           ****            ****            ****
  2           ****            ****               1
  3              0               0               0

FINAL POPULATIONS
JURIS           PL              PM              PH
  1              3             116             127
  2            156              91              81
  3              0               0               0

 TOTAL =     564
```

```
MIGRATION DUE TO UNEMPLOYMENT
           LOW CLASS                                 MIDDLE CLASS                                 HIGH CLASS
FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE        FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE        FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE
JUR-1                                    JUR-1                                    JUR-1
JUR-2                                    JUR-2                                    JUR-2
JUR-3                                    JUR-3                                    JUR-3
OUTSIDE                                  OUTSIDE                                  OUTSIDE

MIGRATION DUE TO UNDEREMPLOYMENT
           LOW CLASS                                 MIDDLE CLASS                                 HIGH CLASS
FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE        FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE        FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE
JUR-1                                    JUR-1                                    JUR-1
JUR-2                                    JUR-2                                    JUR-2
JUR-3                                    JUR-3                                    JUR-3
OUTSIDE                                  OUTSIDE                                  OUTSIDE

MIGRATION DUE TO MOBILITY
           LOW CLASS                                 MIDDLE CLASS                                 HIGH CLASS
FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE        FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE        FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE
JUR-1                                    JUR-1                                    JUR-1
JUR-2                                    JUR-2                                    JUR-2
JUR-3                                    JUR-3                                    JUR-3
OUTSIDE                                  OUTSIDE                                  OUTSIDE

MIGRATION DUE TO PERSONAL DISSAT.
           LOW CLASS                                 MIDDLE CLASS                                 HIGH CLASS
FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE        FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE        FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE
JUR-1                                    JUR-1                                    JUR-1
JUR-2                                    JUR-2                                    JUR-2
JUR-3                                    JUR-3                                    JUR-3
OUTSIDE                                  OUTSIDE                                  OUTSIDE

MIGRATION DUE TO DISPLACEMENT
           LOW CLASS                                 MIDDLE CLASS                                 HIGH CLASS
FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE        FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE        FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE
JUR-1                                    JUR-1                                    JUR-1
JUR-2                                    JUR-2                                    JUR-2
JUR-3                                    JUR-3                                    JUR-3
OUTSIDE                                  OUTSIDE                                  OUTSIDE

MIGRATION DUE TO NATURAL GROWTH
           LOW CLASS                                 MIDDLE CLASS                                 HIGH CLASS
FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE        FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE        FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE
JUR-1                                    JUR-1                                    JUR-1
JUR-2                                    JUR-2                                    JUR-2
JUR-3                                    JUR-3                                    JUR-3
OUTSIDE                                  OUTSIDE                                  OUTSIDE

MIGRATION DUE TO IN-MIGRATION
           LOW CLASS                                 MIDDLE CLASS                                 HIGH CLASS
FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE        FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE        FROM/TO JUR-1 JUR-2 JUR-3 OUTSIDE
JUR-1                                    JUR-1                                    JUR-1
JUR-2                                    JUR-2                                    JUR-2
JUR-3                                    JUR-3                                    JUR-3
OUTSIDE                                  OUTSIDE                                  OUTSIDE
```

2. WATER SYSTEM OUTPUT

Water User Effluent Content

Economic activities, municipal sewer systems, and farms dump effluent into the surface water. All businesses except surface water users dump their effluent into municipal systems, which then can treat some or all of the effluent to varying degrees. This section of the output shows in detail the pollution generated by each farm and economic activity. If a basic industry has a treatment plant, the amount of pollution printed is the pollution remaining in the effluent after treatment. Industries can recycle some water (up to 100%), which decreases the amount of water in the effluent but not the amount of pollution in the effluent.

The amount of each pollutant is expressed on this output as 100 times its actual value. The pollution here is not measured in its concentration per MGD, as it is measured at sampling stations. The pollution is a total volume of pollutant in the effluent. The amount of effluent is also expressed as 100 times its actual value.

Oil and floating solids and high level wastes are represented somewhat differently from the other pollutants. They are either present in the effluent or not; they are not measured in volume or concentration. A zero indicates that the pollutant is absent and a one indicates that the pollutant is present.

For a farm parcel, two rows are printed. The first shows the location of the farm parcel and its type. The second shows the location of the parcel on which the farm parcel's runoff flows, the type of farm dumping on that parcel, and the volume of pollutants and water being dumped there from the farm parcel.

River Quality During Surface Water Process

This output shows the amount of pollution present on a parcel during all stages of the surface water process. A surface water parcel is part of a river. The beginning of a river is defined as a parcel having surface water and on which either no other parcel's surface water dumps or two or more parcels' surface waters dump. The last parcel in a river is a parcel that either dumps on no parcel or dumps on a parcel on which two or more parcels dump.

The parcels are listed in the order in which they are processed, i.e., in sequential order of upstream to downstream for each river. The various stages through which

Figure 2.1

TWOCITY
WATER USER EFFLUENT CONTENT

ROUND 2

LOCATION	TYPE AND LEVEL	TREATMENT TYPE AND LEVEL	PERCENT RECYCLE	BOD (X 100)	CHLORIDES (X 100)	NUTRIENTS (X 100)	COLIFORM (X 100)	TEMPERATURE (X 100)	OIL AND FLOATING SOLIDS	HIGH LEVEL WASTES	WATER PUMPED (MGDX100)
9514	F 2										
9614	F 2	0	0	0	0	20000	0	0	0	0	2000
9914	F 2										
9614	F 2	0	0	0	0	20000	0	0	0	0	2000
9616	F 2										
9616	F 2	0	0	0	0	20000	0	0	0	0	2000
9916	F 2										
9516	F 2	0	0	0	0	20000	0	0	0	0	2000
9618	F 2										
9518	F 2	0	0	0	0	20000	0	0	0	0	2000
9918	F 2										
9618	F 2	0	0	0	0	20000	0	0	0	0	2000
9422	RA 1	0	0	10700	370	770	50	0	1	0	17
9622	RA 1	0	0	6000	180	420	30	0	1	0	6
9822	RA 2	0	0	12000	360	840	60	0	1	0	12
10022	RA 4	0	0	27000	810	1890	135	0	1	0	27
9424	RA 1	0	0	10700	370	770	50	0	1	0	10
9624	RB 2	0	0	84000	2520	5880	420	0	1	0	84
9824	RB 3	0	0	132000	3960	9240	660	0	1	0	132
10024	RB 1	0	0	42000	1260	2940	210	0	1	0	42
10224	RA 4	0	0	42800	1490	3080	200	0	1	0	40
8826	RA 3	0	0	38500	1400	2800	175	0	1	0	35
9026	RA 3	0	0	39500	1400	2800	175	0	1	0	35
9226	RA 3	0	0	38500	1400	2800	175	0	1	0	35
9426	RA 2	0	0	23100	840	1680	105	0	1	0	21
10026	RB 2	0	0	84000	2520	5880	420	0	1	0	84
10226	RA 3	0	0	21000	630	1470	105	0	1	0	21
10826	RA 2	0	0	23100	840	1680	105	0	1	0	21
8628	RA 3	0	0	30000	1200	2400	120	0	1	0	21
8828	RA 4	0	0	53900	1960	3920	245	0	1	0	24
9028	RA 1	0	0	10700	370	770	50	0	1	0	49
9228	PS 1	0	0	1800	0	0	270	0	1	0	17
9928	TF 1	0	70	400000	144000	80000	24000	0	0	0	18
10028	RA 4	0	0	27000	810	1890	135	0	0	0	620
10228	RA 2	0	0	23100	840	1680	105	0	1	0	27
7630	F 1										
7632	F 1	0	0	0	0	48000	0	0	0	0	1500
7830	F 1										
7832	F 1	0	0	0	0	48000	0	0	0	0	1500
8030	F 1										
8032	F 1	0	0	0	0	48000	0	0	0	0	1500
8430	RA 4	0	0	47700	1880	3760	195	0	1	0	33
8630	RA 6	0	0	70000	2800	5600	280	0	1	0	56
8830	RC 1	0	0	153600	5960	11880	645	0	1	0	122
9030	RC 2	0	0	307800	11820	23640	1305	0	1	0	261
9230	PG 1	0	0	5750	0	0	460	0	0	0	23
9630	PA 1	TT 1	60	999072	1265412	29970048	4	0	0	0	26640
9930	RG 1	0	0	2600	0	0	130	0	0	0	13
10030	RA 2	0	0	12000	360	840	60	0	1	0	12
10230	RA 2	0	0	23100	840	1680	105	0	1	0	21
7632	F 1										
7632	F 1	0	0	0	0	48000	0	0	0	0	1500
7832	F 1										
7832	F 1	0	0	0	0	48000	0	0	0	0	1500
8032	F 1										
8032	F 1	0	0	0	0	48000	0	0	0	0	1500
8432	RA 6	0	0	60000	2400	4800	240	0	1	0	48
8632	RA 6	0	0	70000	2800	5600	280	0	1	0	56
8832	RA 2	0	0	17700	680	1360	75	0	1	0	15
9032	RB 3	0	0	156500	6500	13000	690	0	1	0	134
9232	RC 1	0	0	116400	4560	9120	480	0	1	0	95
9432	FO 1	PT 1	0	14700010	1960003	49000000	14702	44100	0	0	4900
9632	MP 1	ST 1	0	4500016	1912502	5625007	4500	135000	0	0	22500
9932	RS 1	0	0	2550	0	0	255	0	0	0	17
10032	RB 2	0	0	115500	4200	8400	525	0	1	0	105
10232	RA 3	0	0	32100	1110	2310	150	0	1	0	32
8634	RA 4	0	0	47700	1880	3760	195	0	1	0	39
8834	RA 3	0	0	30000	1200	2400	120	0	1	0	24
9034	RB 1	0	0	67250	2350	4700	253	0	1	0	50
9234	RB 3	0	0	184000	7200	14400	760	0	1	0	152
9434	RC 1	0	0	144600	5640	11280	600	0	1	0	120
9834	RC 1	0	0	187200	7380	14760	765	0	1	0	153
10234	F 3										
10430	F 3	0	0	0	0	45000	0	0	0	0	2500
10434	F 3										
10430	F 3	0	0	0	0	45000	0	0	0	0	2500
10634	F 3										
10630	F 3	0	0	0	0	45000	0	0	0	0	2500
8836	RA 5	0	0	60000	2400	4800	240	0	1	0	48
9036	RA 2	0	0	20000	800	1600	80	0	1	0	16
9236	RB 1	0	0	59250	2250	4500	255	0	1	0	51
9436	RB 2	0	0	123750	4950	9700	510	0	1	0	102
9636	RB 2	0	0	121750	4650	9300	520	0	1	0	104
9836	RB 2	0	0	122500	4900	9800	490	0	1	0	98
9038	RA 1	0	0	10000	400	800	40	0	1	0	8
9238	RA 1	0	0	10000	400	800	40	0	1	0	8
9438	RA 3	0	0	30000	1200	2400	120	0	1	0	24
9638	RA 4	0	0	47700	1880	3760	195	0	1	0	39
9838	RA 3	0	0	30000	1200	2400	120	0	1	0	24
9616	UT 1	TT 4	0	16840	8492	38970	0	0	0	0	1445
9432	UT 2	TT 4	0	19863	20107	59646	0	0	0	0	1941
0	UT 3	0	0	0	0	0	0	0	0	0	0
0	UT 4	0	0	0	0	0	0	0	0	0	0
0	UT 5	0	0	2550	0	0	255	0	0	0	17

Figure 2.2

```
**********************************************************************************************************************
                                   TRICITY
                              RIVER QUALITY DURING SURFACE WATER PROCESS:   RIVER  2                         ROUND  2
**********************************************************************************************************************

                                                  BOD      CHLORIDES  NUTRIENTS    COLIFORM   TEMPERATURE  AGE OF  AGE OF   AMOUNT
LOCATION  QUALITY          TIME                 (X 100)     (X 100)    (X 100)     (X 100)     (X 100)      OFS     HLW   (MGDX100)
--------  -------  --------------------       ----------  ----------  ----------  ----------  ----------  ------  ------  ---------


  9630      10     FROM OTHER PARCELS              12118        3297      213962          22           0      0       0      49700


  9630      10     AFTER AGING                     12118        3297      213962          22           0      0       0      50000
  9630      10     BEFORE BIO CHANGE                5662        1549       99063          10           0      0       0      23360
  9630      10     AFTER BIO CHANGE                 5404        1385       93904           9           0      0       0      23360
  9630      72     EFFLUENT ADDED                 999072     1265412    29970048           4           0      0       0      26640
  9630      63     MOVED TO NEXT PARCEL          1004476     1266797    30063952          13           0      0       0      50000


  9632      63     AFTER AGING                   1004476     1266797    30063952          13           0      0       0      51000
  9632      63     BEFORE BIO CHANGE              561325      707916    16800432           7           0      0       0      28500
  9632      63     AFTER BIO CHANGE               535810      637124    15702224           6           0      0       0      28500
  9632      92     EFFLUENT ADDED                4500216     1912502     5625007        4500      135000      0       0      22500
  9632      72     MOVED TO NEXT PARCEL          5035826     2549626    21407231        4506      135000      0       0      51000


  9432      72     AFTER AGING                   5035826     2549626    21407231        4506      135000      0       0      52000
  9432      72     BEFORE BIO CHANGE             4581296     2309372    19389984        4081      122279      0       0      47100
  9432      72     AFTER BIO CHANGE              4353964     2078434    18214832        3771           0      0       0      47100
  9432      91     EFFLUENT ADDED               14719873     1980107    49059646       14702       44100      0       0       6941
  9432      91     MOVED TO NEXT PARCEL         19073837     4058541    67274478       18473       44100      0       0      52000


  9232      91     AFTER AGING                  19073837     4058541    67274478       18473       44100      0       0      53000
  9232      91     BEFORE BIO CHANGE            19073837     4058541    67274478       18473       44100      0       0      53000
  9232      91     AFTER BIO CHANGE             18206832     3652686    63197216       17073           0      0       0      53000
  9232       0     EFFLUENT ADDED                      0           0           0           0           0      0       0          0
  9232      91     MOVED TO NEXT PARCEL         18206832     3652686    63197216       17073           0      0       0      53000


  9032      91     AFTER AGING                  18206832     3652686    63197216       17073           0      0       0      54000
  9032      91     BEFORE BIO CHANGE            18206832     3652686    63197216       17073           0      0       0      54000
  9032      91     AFTER BIO CHANGE             17379248     3287417    59367072       15779           0      0       0      54000
  9032       0     EFFLUENT ADDED                      0           0           0           0           0      0       0          0
  9032      91     MOVED TO NEXT PARCEL         17379248     3287417    59367072       15779           0      0       0      54000


  8832      91     AFTER AGING                  17379248     3287417    59367072       15779           0      0       0      55000
  8832      91     BEFORE BIO CHANGE            17379248     3287417    59367072       15779           0      0       0      55000
  8832      91     AFTER BIO CHANGE             16589283     2958675    55769056       14583           0      0       0      55000
  8832       0     EFFLUENT ADDED                      0           0           0           0           0      0       0          0
  8832      91     MOVED TO NEXT PARCEL         16589283     2958675    55769056       14583           0      0       0      55000


  8632      81     AFTER AGING                  16589283     2958675    55769056       14583           0      0       0      56000
  8632      81     BEFORE BIO CHANGE            16589283     2958675    55769056       14583           0      0       0      56000
  8632      81     AFTER BIO CHANGE             15835224     2662807    52389104       13478           0      0       0      56000
  8632       0     EFFLUENT ADDED                      0           0           0           0           0      0       0          0
  8632      81     MOVED TO NEXT PARCEL         15835224     2662807    52389104       13478           0      0       0      56000


  8432      81     AFTER AGING                  15835224     2662807    52389104       13478           0      0       0      57000
  8432      81     BEFORE BIO CHANGE            15835224     2662807    52389104       13478           0      0       0      57000
  8432      81     AFTER BIO CHANGE             15115441     2396526    49214000       12456           0      0       0      57000
  8432       0     EFFLUENT ADDED                      0           0           0           0           0      0       0          0
  8432      81     MOVED TO NEXT PARCEL         15115441     2396526    49214000       12456           0      0       0      57000


  8232      81     AFTER AGING                  15115441     2396526    49214000       12456           0      0       0      58000
  8232      81     BEFORE BIO CHANGE            15115441     2396526    49214000       12456           0      0       0      58000
  8232      81     AFTER BIO CHANGE             14428375     2156873    46231328       11512           0      0       0      58000
  8232       0     EFFLUENT ADDED                      0           0           0           0           0      0       0          0
  8232      81     MOVED TO NEXT PARCEL         14428375     2156873    46231328       11512           0      0       0      58000


  8032      81     AFTER AGING                  14428375     2156873    46231328       11512           0      0       0      59000
  8032      81     BEFORE BIO CHANGE            14428375     2156873    46231328       11512           0      0       0      59000
  8032      81     AFTER BIO CHANGE             13772539     1941185    43429424       10639           0      0       0      59000
  8032      23     EFFLUENT ADDED                      0           0       96000           0           0      0       0       3000
  8032      81     MOVED TO NEXT PARCEL         13772539     1941185    43525424       10639           0      0       0      59000


  7832      81     AFTER AGING                  13772539     1941185    43525424       10639           0      0       0      60000
  7832      81     BEFORE BIO CHANGE            13772539     1941185    43525424       10639           0      0       0      60000
  7832      81     AFTER BIO CHANGE             13146514     1747066    40887520        9833           0      0       0      60000
  7832      67     EFFLUENT ADDED                     35          36       96037          38          15      6       0       3001
  7832      81     MOVED TO NEXT PARCEL         13146549     1747102    40983557        9871          15      6       0      60000


  7632      81     AFTER AGING                  13146549     1747102    40983557        9871          15      0       0      61000
  7632      81     BEFORE BIO CHANGE            13146549     1747102    40983557        9871          15      0       0      61000
  7632      81     AFTER BIO CHANGE             12548978     1572391    38595696        9123           0      0       0      61000
  7632      23     EFFLUENT ADDED                      0           0       96000           0           0      0       0       3000
  7632      81     MOVED TO NEXT PARCEL         12548978     1572391    38595696        9123           0      0       0      61000


  7432      81     AFTER AGING                  12548978     1572391    38595696        9123           0      0       0      62000
  7432      81     BEFORE BIO CHANGE            12548978     1572391    38595696        9123           0      0       0      62000
  7432      81     AFTER BIO CHANGE             11978569     1415151    36256560        8431           0      0       0      62000
  7432       0     EFFLUENT ADDED                      0           0           0           0           0      0       0          0
  7432      81     MOVED TO NEXT PARCEL         11978569     1415151    36256560        8431           0      0       0      62000
```

water is processed are grouped together for a single parcel. The water quality is expressed by a two-digit code, the first digit of which represents the water quality category and the second of which represents the first pollutant type which placed the water quality in that category (1=BOD, 2=Chlorides, etc.). The volumes of the first five pollutant types are expressed as 100 times their actual values.

The values printed for the last two pollutant types, oil and floating solids and high level wastes, are their "ages". Each of these pollutants disappears from the river water after travelling five parcels down the river. Whenever two rivers meet or effluent is dumped into the surface water, the "age" of that pollutant in the surface water becomes the "age" of the youngest source of that pollutant. So, if the surface water had high level wastes age 4 and high level wastes were dumped on the parcel, the new age of that pollutant would be 1.

For each parcel, the pollutant content of the water is given for five different stages. The first, "AFTER AGING", shows no difference in pollutant content from the previous parcel except for the ages of oil and floating solids and high level wastes. Their ages are incremented by one (if the previous age was not zero) until they are greater than 5, in which case they disappear from the river and become age zero. The volume of water is the volume of surface water on the parcel.

"BEFORE BIO CHANGE" is the amount of pollution in the surface water after water has been removed by any intake on the parcel. When water is removed from a parcel, the pollution in that water is also removed. So, if one third of the water on a parcel were removed, one third of the pollution would also be removed. Only oil and floating solids and high level wastes are unaffected when water is removed. The volume of water printed on this line is the volume remaining in the surface water after any water is removed.

After water is removed from the surface water, the remaining pollution undergoes a biodegration process. The third line, "AFTER BIO CHANGE", shows the amount of pollution in the river after that decay process.

Water is dumped on parcels containing municipal outflow points, basic industry surface water users, and agricultural runoff points. The total amount of pollution added to the surface water on a parcel is the fourth line, "EFFLUENT ADDED". That pollution is added together with the pollution remaining in the river after biodegradation, and the result is moved to the next parcel in the river. The total amount of pollution leaving a parcel is shown on the fifth line, "MOVED TO NEXT PARCEL".

For those parcels on which municipal intake points are located, the program prints the utility district code number and amount of water removed by the district on a line between "AFTER AGING" and "BEFORE BIO CHANGE". The amount of water printed is shown as 100 times its actual value.

Water User Costs and Consumption

All water users except farms can incur costs related to water. The types of possible expenditures vary by the type of water user. Prices paid by municipal water users purchasing locally are set by jurisdiction and by type of user.

One cost for use of water can be incurred by any water user: if a water user cannot obtain all of its needed water from its normal source, it automatically purchases the remainder from the Outside at the Outside price per unit of water. Actually the Outside price does not necessarily literally represent a purchase from sources outside of the simulated region; it merely represents a higher cost to a water user to obtain or process its required water. Regardless of how a business obtains its water requirement, it dumps all of its effluent into a municipal system, or if it is a surface water user, into the surface water on its parcel.

A municipal water user obtains all of its needed water from its municipal system unless: 1) the total amount of water attempted removed by surface water users (municipal intake points or surface water using basic industries) from the parcel on which its municipal intake point is located is greater than the amount of water on the parcel; 2) the water quality on the parcel on which its municipal intake point is located is 9; 3) the intake treatment plant of its municipal system has the capacity to process less than the total water requirement of the municipal system's water users. In the second case, no water users supplied by the municipal system receive municipal water; all purchase from the Outside. In the first and third cases each water user receives a share of the municipally-supplied water proportionate to its needs. If both the first and third cases obtain, the lesser amount is removed from the surface water and treated. A business pays the local price set for its business type for that proportion of its annual requirement which is supplied locally and pays the Outside price for that proportion which is not supplied locally.

Figure 2.3

```
**************************************************************************************************************************************
                         TWOCITY
                 WATER USER COSTS AND CONSUMPTION                                                                            ROUND  2
**************************************************************************************************************************************

            TYPE                                   AMOUNT     AMOUNT      ANNUAL       ANNUAL                  INTAKE      OUTFLOW
             AND                       UTILITY    REQUIRED   OBTAINED  CONSUMPTION     WATER     RECYCLING   TREATMENT   TREATMENT
LOCATION   LEVEL   JURISDICTION       DISTRICT     (MGD)      (MGD)       (MG)         COST        COST        COST        COST
--------   -----   ------------       --------   --------   --------  -----------  ----------  ----------  ----------  ----------

   9422    RA 1          1                1         0.10       0.10        36         14580           0           0           0
   9622    RA 1          2                2         0.06       0.01        21         14220           0           0           0
   9822    RA 2          2                2         0.12       0.02        43         28440           0           0           0
  10022    RA 4          2                2         0.27       0.04        97         64440           0           0           0
   9424    RA 1          1                1         0.10       0.10        36         14580           0           0           0
   9624    RB 2          2                2         0.84       0.13       302        199930           0           0           0
   9824    RB 3          2                2         1.32       0.20       475        314640           0           0           0
  10024    RB 1          2                2         0.42       0.06       151        100440           0           0           0
  10224    RA 4          2                2         0.40       0.06       144         95400           0           0           0
   8826    RA 3          1                1         0.35       0.35       126         56700           0           0           0
   9026    RA 3          1                1         0.35       0.35       126         56700           0           0           0
   9226    RA 3          1                1         0.35       0.35       126         56700           0           0           0
   9426    RA 2          1                1         0.21       0.21        75         34020           0           0           0
   9626    CR 0          2                2         0.0        0.0          0             0           0           0           0
  10026    RB 2          2                2         0.84       0.13       302        199930           0           0           0
  10226    RA 3          2                2         0.21       0.03        75         50220           0           0           0
  10426    RA 2          2                2         0.21       0.03        75         50220           0           0           0
   8628    RA 3          1                1         0.24       0.24        86         17280           0           0           0
   8828    RA 4          1                1         0.49       0.49       176         79380           0           0           0
   9028    RA 1          1                1         0.10       0.10        36         14580           0           0           0
   9228    RS 1          1                1         0.18       0.18        55         25110           0           0           0
   9428    WF 0          1                1         0.0        0.0          0             0           0           0           0
   9828    IF 1          2                2         5.20       0.79      1352        885560      291200           0           0
  10028    RA 4          2                2         0.27       0.04        97         64440           0           0           0
  10228    RA 2          2                2         0.21       0.03        75         50220           0           0           0
   8430    RA 4          1                1         0.39       0.39       140         34380           0           0           0
   8630    RA 6          1                1         0.56       0.56       201         40320           0           0           0
   8830    RC 1          1                1         1.29       1.29       464        200990           0           0           0
   9030    RC 2          1                1         2.61       2.61       939        422819           0           0           0
   9230    RG 1          1                1         0.24       0.23        71         32085           0           0           0
   9630    PA 1          2                2       266.40     266.40     69764             0     6926400     1385280           0
   9830    RG 1          2                2         0.13       0.02        40         26660           0           0           0
  10030    RA 2          2                2         0.12       0.02        43         28440           0           0           0
  10230    RA 2          2                2         0.21       0.03        75         50220           0           0           0
   8432    RA 6          1                1         0.48       0.48       172         34560           0           0           0
   8632    RA 6          1                1         0.56       0.56       201         40320           0           0           0
   8832    RA 2          1                1         0.15       0.15        54         17100           0           0           0
   9032    RB 3          1                1         1.38       1.38       496        223560           0           0           0
```

A surface water user obtains all of its needed water from the surface water unless: 1) the surface water quality is 9; 2) the total amount of water attempted removed from the parcel by itself and any municipal intake points located on the parcel is greater than the amount of water on the parcel. In the first case the industry buys all of its water from the Outside at the Outside price per unit of water. In the second case, the industry receives from the surface water an amount proportionate to its requirement and buys the remainder from the Outside.

On this output, the number printed under AMOUNT REQUIRED is the water user's daily water requirement. The AMOUNT OBTAINED is the amount of water obtained from the water user's normal source of water. The annual consumption is a function of the activity's type, level, and, in the case of basic industries, amount of recycling. The annual water cost is the total cost which the activity pays for water in that round. A surface water user which obtains all of its water from the surface water has zero cost here.

Only surface water using basic industries can incur recycling, intake treatment, and outflow treatment costs. A business's recycling cost is a function of its amount of recycling and its normal water requirement. Its intake treatment cost has an additional variation for the quality of the intake water before it is processed. Outflow treatment costs vary by the industry's volume of effluent and the type of treatment provided. All three costs are shown on this output as total annual costs.

Coliform and Pollution Index Values (Map)

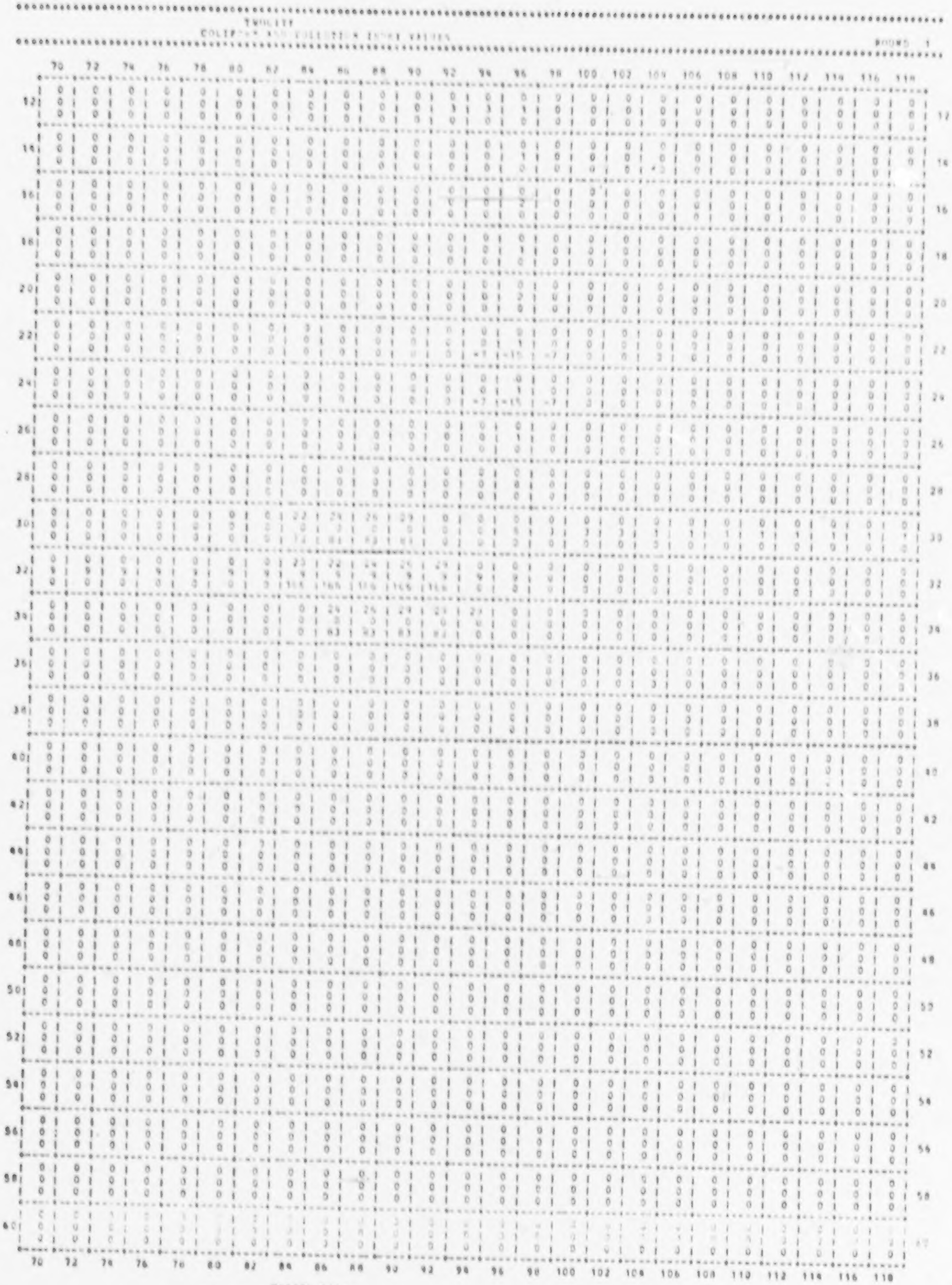
The coliform concentration in the surface water on a parcel affects the health index of that parcel and adjoining parcels. A parcel adjoins a surface water parcel if any of its corners touches a surface water parcel's corner. The coliform count on a parcel which adjoins a surface water parcel is the highest count of all of the surface water parcels which it adjoins. When used in a parcel's health index, the coliform count is divided by 4 and can have a maximum value of 50.

A parcel's pollution index contributes to its environmental index. It is one of two indexes in the model which can be negative; good water quality contributes to the desirability of surface water parcels and bordering parcels. For a parcel containing surface water, the pollution index is:

$$(W-3.5)^3$$

where W is the surface water quality rating.

Figure 2.4


TWQLITY
COLIFORM AND POLLUTION INDEX VALUES
ROUND 1

PARCEL KEY:
TOP ROW: COLIFORM COUNT
MIDDLE ROW: WATER QUALITY RATING
BOTTOM ROW: POLLUTION INDEX

The pollution index of a parcel bordering a surface water parcel on a full side is half of the average pollution indexes of the surface water parcels which it borders.

Pollution indexes are calculated for lake parcels and parcels bordering lake parcels. Since the concentration of individual pollutants is never specified for lake parcels, there are no coliform counts for them.

3. EMPLOYMENT OUTPUT

The Full-Time Employment and Transportation Processes

The employment allocation process is run soon after the migration process. The number of workers living at each residence location is the number resulting from migration. Unlike the migration process, the employment process operates on all Pl's; each Pl reconsiders all job openings each round. A whole Pl is hired at a time; there is no smaller unit in employment than a Pl, even though a Pl is composed of many workers.

The factors involved in the matching of workers with jobs are each employer's salary offerings (salaries are set by class, one salary offered to each class), the transportation costs for workers to get to employment locations, the workers' relative education levels, the number of job openings in each class, where workers were employed in the previous round, and where workers are boycotting job openings. In general, if there are fewer workers than jobs, those employers offering the lowest salaries or located farthest from residences do not receive all of their needed employees and suffer production losses. Likewise, if there are more workers than jobs, those workers with the lowest education levels or located farthest from jobs are unable to find employment.

The process operates on one class at a time, high-income first and low-income last. Any high-income workers who cannot find jobs are first to be considered for middle-income jobs, and any middle-income workers who cannot find middle-income jobs are the first to be considered for low-income jobs. Thus, unemployment tends to be pushed toward the lower classes, although that is not always the case.

The first part of the employment process is the selection of the least cost route from each class living on a residence parcel to each employment location. When a population group selects a least cost route, it evaluates both the time (dollar value of time) and actual dollar cost of each mode and route. Modal usage is also a factor, since overcrowded modal usage causes delay in time. The workers perceive the previous round's mode and route usage. Each class is willing to pay up to a fixed percent of the income which it would earn at a job in order to get to the job.

After the least cost route has been selected from each Pl's residence to each employment location, each Pl applies for the job which nets it the greatest amount of money (salary offered less the transportation cost to get there). A P1 perceives a somewhat higher salary at its previous job than is actually offered there. If the net income which the P1 would receive at its old job is perceived to be highest, the P1 takes its old job back and looks no further. A P1 does not even consider taking a job which it is boycotting.

After all P1's who find their old jobs to be their best jobs have taken their old jobs, the remaining P1's seeking employment compete for jobs on the basis of their educational levels. Of the applicants for remaining job openings, an employer selects those with the highest education levels first. Those P1's who are not hired for their best jobs then seek employment at their next best jobs. The process is repeated until either all of the job openings in the class have been filled or all of the P1's in the class have been hired. There is one type of exception to the latter case: a P1 which cannot find a job within its maximum transportation range remains unemployed.

The employment process then operates on the next lower class, any P1's from the previous class being the first considered for jobs.

After the employment process has been run for all three classes, transportation routes and congestion are recalculated using the origins and destinations created in the employment process. All classes are assigned simultaneously to the least cost routes in time and money from their residences to their jobs, considering the previous round's usage of modes and routes. If there are any great changes in congestion between rounds after all have been assigned routes, the transportation process is run again, considering the new usage. The process is repeated until there is no great change in congestion between two successive iterations. P1's pay only the final actual dollar cost to travel; the time dollar cost is used for route allocation only.

The Full-Time Employment and Transportation Output

Detailed employment information prints for each class, low-class first and high-income last. Within a single class's output all of the information pertaining to those of the class living on the same residence parcel is printed together. The order in which the information for each parcel is printed is from left to right, top to bottom across the board.

The first column contains the coordinates of the residence parcel. The next column contains the location of

Figure 3.3

```
                         EMPLOYMENT SELECTION INFORMATION FOR   HIGH INCOME CLASS

RESIDENCE  EMPLOYER  POPUL.  SALARY  TIME  AUTO  BUS   RAIL   ROUTE
LOCATION  LOCATION  UNITS           UNITS COST  COST  COST

  8628   UNEMPLOYED    0

          9828         3   11000.  35.0 935.0  0.0   0.0     9727    9527    9327    9127    8927    8727

  8430   UNEMPLOYED    4

  8630   UNEMPLOYED    5

          9828         2   11000.  25.0 985.0  0.0   0.0     9727    9527    9529    9531    9331    9131    8931
                                                             8731

  8830   UNEMPLOYED    0

          9230 (SC2)   2   10600.   2.5 310.0  0.0   0.0     9131    8931
          9630         1   11000.   7.5 510.0  0.0   0.0     9531    9331    9131    8931
          9432        10   11000.   5.0 410.0  0.0   0.0     9331    9131    8931

  9030   UNEMPLOYED    1

          9228         4   10000.   2.5   0.0  0.0   0.0     9129
          9828        16   11000.  20.0 785.0  0.0   0.0     9727    9527    9529    9531    9331    9131
          9630         1   11000.   5.0 410.0  0.0   0.0     9531    9331    9131
          9832         1   10000.   7.5 510.0  0.0   0.0     9731    9531    9331    9131

  8432   UNEMPLOYED    6

  8632   UNEMPLOYED    6

          9828         1   11000.  25.0 985.0  0.0   0.0     9727    9527    9529    9531    9331    9131    8931
                                                             8731
```

each employer for which P1's in the class on the parcel work. The first row always shows the number of P1's who are unemployed on the parcel. For each other row, the output shows the number of P1's working at the employment location, the salary earned per worker, the total number of time units spent traveling to work, the total automobile cost paid per worker, the total bus cost paid per worker, the total rail cost paid per worker, and the route and modes which the population units take to work. All P1's of the same class living on the same residence parcel and working for the same employer take the same route and modes. The route printed is traced from employment location to residence location. The intersection at the start of travel, the intersections passed, the intersection at which a new mode is used, and the last intersection (that of the residence parcel) are listed in order. An intersection is a four or five digit number which may be preceded by a bus or rail route number if the P1 got off the bus or rail system at that intersection.

Next to some employment locations are parentheses containing the name of a government department or the notation 'FSE'. A government department has a parcel designated as its employment center. That parcel does not necessarily have government activity on it; it is merely used as a central hiring location because although a department can have facilities on several parcels, it hires centrally as a whole. The letters 'FSE' denote Federal-state employment centers such as state departments and federal installations. FSE is a catch-all category for miscellaneous local employment. An FSE only hires; it has none of the other characteristics of a business or local government department.

The Part-Time Employment Process

A social decision-maker can allocate time units for his population units to spend in part-time work. Social decision-makers realize that their population units seldom receive all the extra work for which time was allocated. As with the full-time employment allocation process, the P1's educational level is the most important factor in the assignment of part-time work units to extra work time allocation.

The supply of part-time work units, eighty of which are equivalent to one full-time job, is primarily determined by the levels of business activity in the system. Each business type has a fixed number of time units of part-time work for each class for each level of operation. In addition, a variable number of part-time work units (jobs) is provided by the School Department.

The school department in each jurisdiction provides public adult education according to the number of middle and high-income part-time work units it hires. This specification obviously can fluctuate considerably round-to-round.

Two lists -- one supply of and the other demand for part-time work units -- are created for each population class. The suppliers of part-time work units are ordered by the salary offered (proportional to full-time wage offered) with the highest salary placed first. Each entry on this list contains a location, a full-time salary per worker, and an amount of part-time work units available.

Each entry in the demand for units list is comprised of a residence group for which allowed time for extra work as defined by a parcel location, an average education level, and an average time allocation for extra work.* The number of Pl's in each group is the final item of information. This list is ordered on the basis of average education level with the highest levels first.

For each complete pass through the list of residence groups, the part-time work allocation process attempts to assign by class ten units of extra work to each population unit which has an unfilled extra work allocation. The process continues until either all requests (unfilled allocations) are filled or until the supply of part-time work units is exhausted.

First, the residence group at the top of the list (i.e., the one with the highest education level of those groups who have not yet been assigned work in that particular pass) is examined. The number of Pl's is multiplied either by ten or by a figure less than ten (if there are less than ten unfilled extra work time allocation units remaining) in order to obtain the group's request for part-time work units. For example, assume in the first pass that 6 PH's at 10026 have the highest education level and that the social decision-maker allocated 25 time units to extra work for each PH. The total demand for units of this group in the first pass is sixty (60). These population units will have their employment request of sixty part-time units met before any other high-income population units are considered.

---

*Pl's of the same class who live on the same parcel. Each Pl so grouped has averaged, and thus identical, characteristics such as education level and time allocated for extra work.

Once the request is determined, the job supply list is examined. For each potential work location, a shadow automobile transportation cost per worker is calculated. This value is subtracted from the salary per worker to obtain a net income per worker which is used to determine the best job. Units from this best job are assigned to the residence group up to the amount of their request. If that particular job has an insufficient supply of part-time units available, the remainder of the request must be met by the second best job, and so on.

After the job units are assigned to the particular residence group, their per P1 unfilled extra work time allocation units are decremented by ten (or the figure less than ten) and they are placed at the bottom of the residence group list. Of course, if the residence then has no more units to be filled, they are dropped from further consideration.

Subsequently, a different residence group appears at the top of the list and the assignment process proceeds in the identical fashion. This continues until either of the two mentioned termination criteria are reached. High-income population units may not be assigned middle or low-income part-time jobs, nor may middle take low or high, and so forth. Within an income class, the only case in which a P1 would receive a part-time job before another P1 with a higher education level is the case in which the latter's shadow transportation cost exceeded the remuneration expected from the particular job.

Note: The route which a P1 takes to a part-time job is the least-cost route, but road congestion is not a factor, and auto is the only mode allowed. The costs used in part-time job and route selection are the peak-hour transportation parameters, but a P1 pays a dollar cost and spends an amount of time travelling proportional to the number of time units spent in part-time work. For example, if a P1 spends 20 time units at a job to which the least full-time transportation cost is $200 and 4 time units, the P1 is charged 20/80 of those amounts, or $50 and 1 time unit.

The base auto cost used in the trip to full-time employment is used as a base cost in part-time employment, so a P1 also pays a portion of that base cost to get to part-time work.

The Part-Time Employment Output

One output is printed for each class, high-income first and low-income last. The first column shows the coordinates of the residence parcel. The second shows the location of one employer for whom the class on the parcel has been assigned part-time work. The location 'ADED' indicates that the class is working for a School Department's adult education program. The third column is the total number of part-time work units which the class on the parcel is filling at the employment location. The fourth contains the full-time salary offered per worker at the employment location. Since a full-time job is equivalent to 80 time units in part-time work, a class which filled 60 time units at a particular employer would receive 60/80 of the total salary paid to a P1 in its class working there full-time.

Figure III 3.4

```
PART-TIME WORK ALLOCATION FOR   HIGH INCOME CLASS

RESIDENCE  EMPLOYER   TIME UNITS   SALARY
-----------------------------------------


   8830        9230         100      10600.
   8830        9630          30      11000.
   9833        9632          30      11000.
   8836        9630          50      11000.
   8836        9632          10      11000.
   9638        9632          40      11000.
   9834        9832          90      10000.
   9934        9430         130      10500.
   9438        9430          30      10500.
   9034        9828          50      11000.
   9436        9430          20      10500.
   9436        9828          30      11000.
   9436        9830          60      10000.
   8430        9830          20      10000.
```

Employment Summary

This shows overall employment statistics for the simulated region. The list includes the following summary information for each class: the number of residence parcels occupied by the class; the number of Pl's employed in jobs of their own class; the number of Pl's taking jobs in the next lower class; the number of unemployed Pl's; the total number of Pl's in the class living in the simulated region; the total number of part-time units worked by the class; and the number of job openings for the class which were left unfilled.

This output is the single most useful section of the employment output for an observer to use in quickly evaluating the local employment situation.

Employment Centers

This output lists information concerning Federal-state employers and the locations of local government employment centers. The director specifies where Federal-state employers are located, how many Pl's they attempt to hir, and the salaries they offer. This output shows that information and the number of jobs which were actually filled at each Federal-state employment location.

The director can also designate locations from which a local government department hires. If the director does not designate a parcel as a department's employment center, that department has the whole region as its hiring location. That is, a prospective employee has no location to which to travel for work. An employee's transportation time and dollar cost is the average automobile time and dollar for workers in the region. He does not contribute to road usage because he has no specific destination.

Figure 3.7

EMPLOYMENT SUMMARY

	LOW INCOME	MIDDLE INCOME	HIGH INCOME	ALL CLASSES
NUMBER OF RESIDENCES	20	35	31	52
PI'S EMPLOYED AT THIS LEVEL	173	236	274	683
PI'S EMPLOYED AT LOWER LEVEL	0	79	42	121
PI'S UNEMPLOYED	41	0	0	41
TOTAL POPULATION UNITS	214	315	316	845
PART-TIME UNITS WORKED	1304	1648	1008	3960
NUMBER OF JOBS STILL AVAILABLE	0	0	0	0

Figure 7.2

```
**********************************************************************
                               TWOCITY
                          EMPLOYMENT CENTERS                            ROUND  2
**********************************************************************
  FEDERAL STATE EMPLOYERS
  -----------------------

  EMPLOYER       JOB OPENINGS           JOBS FILLED          SALARY OFFERED
  LOCATION    LOW  MIDDLE  HIGH     LOW  MIDDLE  HIGH     LOW  MIDDLE  HIGH
  --------    ---  ------  ----     ---  ------  ----     ---  ------  ----

    9432        5     4      3        5     4       3    2600   5200  10400

  LOCAL GOVERNMENT EMPLOYERS
  --------------------------
  DEPT. AND JURIS.   EMPLOYMENT CENTER
  ----------------   -----------------
       RAIL                9430

        BUS                9430

        MS1                9430

        SC1                9430

        MS2                9230

        SC2                9230
```

4. COMMERCIAL OUTPUT

The Commercial Allocation Process

All people and businesses and two government departments purchase goods and services each round in order to function. People and residence owners (for residential maintenance) purchase from Personal Goods (PG) and Personal Services (PS) establishments; businesses, schools, and municipal services purchase from Business Goods (BG) and Business Services (BS) establishments. The procedures for allocation of PG and PS buyers to sellers are identical. The procedures for allocation of BG and BS buyers to sellers are similar to the PG and PS allocation and identical to each other. The computer program performs the entire allocation process, but is affected by player decisions.

Each user of goods and services requires a certain number of consumption units. A consumption unit is an expression which represents a quantity to be purchased, regardless of what items in reality comprise that quantity. The quantity of goods or services which a seller can provide is also expressed as a certain number of consumption units. Each seller of goods or services sets a price which must be paid for each consumption unit purchased at his commercial establishment. Usually PG and PS prices are similar and BG and BS prices are similar. The quantity which each buyer of goods and services must obtain is indirectly derived from player decisions by the computer program. The program relates the local supply to that demand in the commercial allocation process, which simulates the decision of each buyer as to where it will purchase its required goods and services.

The PG-PS allocation process is run before the BG-BS allocation process. A description of PG allocation suffices as a PS description.

The buyers of PG are each class living on each residence parcel and each residence unit incurring maintenance. Pl's buy for themselves to live; residence owners buy goods for maintenance only. All of the same class living on the same residence parcel purchase at the same PG; a residence owner buys all of a single residence parcel's maintenance at the same PG.

Each buyer of PG attempts to purchase from the PG establishment at which it can obtain its goods most cheaply. The buyer's cost per consumption unit (CU) is the cost per CU at the establishment plus the least transportation cost per CU to get from the buyer's location to the establishment. There are two additional factors in a buyer's perception of a seller's price. One is the buyer's bias toward shopping where it shopped in the previous round. The other is the buyer's bias against shopping at an establishment which was overused in the previous round, i.e., an establishment at which more CU's were sold than the establishment could adequately provide. There is no absolute limit on the amount which a PG can sell, but as it sells more than its effective capacity to provide, its service deteriorates.

Each buyer selects the PG establishment at which it incurs the least perceived total cost. A buyer does not even consider selecting a PG which it is boycotting. All buyers choose simultaneously, and then reevaluate their selections in light of the new usage. The evaluation process is repeated until no commercial establishment changes its usage on two successive reevaluations. The cost which a buyer pays is the actual price at the PG which it selects and the actual least transportation cost to get to that PG.

There is one competitor for local PG establishments: the Outside. The Outside is treated the same as any other PG in the allocation process, but its price is higher than the typical local price (see Master Tables for Outside prices and typical local prices). There is, however, no transportation cost to shop Outside, and no crowding effect. A PG buyer purchases Outside if the Outside price is less than its least perceived local cost to shop. The Outside has unlimited capacity.

Output

There are four main parts to the commercial output:

PERSONAL GOODS ALLOCATION SUMMARY
PERSONAL SERVICES ALLOCATION SUMMARY
BUSINESS GOODS ALLOCATION SUMMARY
BUSINESS SERVICES ALLOCATION SUMMARY

Again, an explanation of PG applies, to a great extent, to the other allocations.

The first section concerns PG establishments. Each PG has a code number. The Outside is always code number one. In the row beside the code number are the location of the PG, its owner, development level, effective capacity (in CU's), the number of CU's sold, the price charged per CU, and the PG's gross income (price per CU times CU's sold). The Outside has no owner, level, or capacity.

Figure 4.1

```
******************************************************************************************************
                 TWOCITY
                 PERSONAL GOODS  ALLOCATION SUMMARY                                          ROUND  2
******************************************************************************************************

                                          PERSONAL GOODS
                                       ------------------

   NUMBER   LOCATION   OWNER   LEVEL   CAPACITY   CAPACITY USED   PRICE/CU   GROSS INCOME
   ------   --------   -----   -----   --------   -------------   --------   ------------

     1          OUTSIDE                                4144         13000       53872000.

     2         9230      E       1       13148         13822         10000      138220000.

                                         TOTAL         17966                    192092000.


                                          CUSTOMERS
                                          ---------

 PERSONAL GOODS                CLASS OR   DECISION MAKER   CONSUMPTION   TRANSPORTATION   PURCHASE     TOTAL
 ASSIGNED TO       LOCATION    LAND USE    CONTROLLING        UNITS           COST           COST        COST
 --------------    --------    --------   --------------   -----------   --------------   --------     -----

      2              9422         RA            B                 1            1175.         10000.      11175.
      2              9422         LOW           F                21           24675.        210000.     234675.
      2              9422         MID           C                23           32900.        280000.     312900.
      2              9622         LOW           D                42           49350.        420000.     469350.
      1              9822         LOW           D                84               0.       1092000.    1092000.
      1             10022         LOW           D               190               0.       2470000.    2470000.
      2              9424         RA            C                 2            1850.         20000.      21850.
      2              9424         LOW           F                21           19425.        210000.     229425.
      2              9424         MID           C                28           25900.        280000.     305900.
      2              9624         RB            F                52           48100.        520000.     568100.
      2              9624         LOW           D               590          545750.       5900000.    6445750.
```

The second section provides detail on all purchases of PG. The table contains one row for each purchaser of PG. The list is ordered by residence parcel location, from left to right and top to bottom across the board. For a single parcel, the list is in order of residence, low-income, middle-income, high-income. The first column contains the code number of the PG at which the buyer is shopping. The second column contains the coordinates of the residence parcel and the third identifies the type of buyer on the residence parcel (RA, RB, RC, LOW, MID, or HIGH). Next is a single letter identifying the decision-maker controlling the residence or class. For a residence, the letter denotes an economic decision-maker; for a class, the letter denotes a social decision-maker.

The number of consumption units which the buyer has obtained is the fifth item of information. The number of CU's required is calculated by the program but is affected by player decisions. The calculations are different for residential maintenance than for Pl's. A residence depreciates each round in response to several factors: normal depreciation (fixed), quality of local municipal services, sufficiency of local water for fire protection, and floods. Only the normal depreciation is not responsive to local conditions. As a residence depreciates, it becomes less attractive to people seeking housing. A residence owner can offset depreciation by setting a maintenance level for the residence. When the residence depreciates below that maintenance level, the program automatically calculates the number of PG and PS units required to restore the residence to the maintenance level. The values of the factors which affect depreciation and the number of PG and PS units required for each 1% maintenance are shown on the Master Tables. For example, suppose that an RB had a quality index of 70 and a maintenance level of 70, and that the Master Table showed that RB requires 4 PG units and 2 PS units per 1% maintenance. Suppose that the residence depreciated a total of 3% (3% of 100, not of 70). The RB would automatically purchase 3 x 4, or 12 units of PG, and 3 x 2, or 6 units of PS.

The total consumption of a class living on a single residence parcel is a function of three things: the class, the amount of time allocated to recreation, and the number of Pl's in the class living there. The fixed number of PG and PS units required by a Pl in each class are shown on the Master Table. The amount of time allocated to recreation is set by the decision-maker controlling the class on the parcel. The Master Table shows the number of PG and PS units which a Pl must purchase for each time unit spent in recreation. Suppose that there are 6 PM's on a parcel and that they have allocated 10 time units to recreation.

Suppose further that the Master Table shows that a PM requires 28 PG and 11 PS units per round, and .05 PG and .05 PS units per time unit in recreation. The 6 PM's would require:

28 x (10 x .05) x 6 = 84 PG units, and 11 x (10 x .05) x 6 = 33 PS units.

The transportation cost, the sixth column, is the total transportation cost which the buyer pays to obtain PG. The transportation cost is always zero if the buyer purchases from the Outside. The transportation costs printed for residences are dummy costs used for the purposes of assigning residential maintenance purchases to PG establishments; no one ever pays that cost.

The last two columns show the total purchase cost paid by the buyer to the PG establishment and the total cost paid by the buyer for the personal goods and transportation (columns six plus seven).

The Personal Services Allocation Summary contains the identical types of information regarding detail on buyers and sellers of personal services.

The Business Goods and Business Services summaries are also identical regarding economic sector buyers and sellers, with a few minor exceptions in the economic sector. For one, PG and PS buy from BG and BS in response to their sales resulting from the personal commercial allocation. The Master Table shows how many units of BG and BS a PG or PS must purchase for each CU which it sells.

A basic industry requires a fixed number of BG and BS units each round. The fixed number is the number which the Master Table shows as being required for a level one of the industry type. That amount times the industry's level is the industry's fixed consumption.

Businesses depreciate annually due to several factors. Like residences, businesses may offset depreciation through maintenance. The Master Table shows the number of BG and BS units required per 1% maintenance for each business type.

Business Goods and Business Services are the only business types which never pay for operating costs and maintenance costs locally. They purchase from the Outside.

The major difference between the BG-BS and PG-PS allocation processes is that BG and BS can have contracts to provide local schools and municipal services departments with their required goods and services. A department can

Figure 4.5

```
                    GOVERNMENT CONTRACTS
                    ---------- ---------

BUSINESS SERVICES  DEPARTMENT     CONSUMPTION UNITS    COST
-----------------  ----------     -----------------    ----


        1             MS1                      3           390000

        1             MS2                      8          1040000
```

FILMED FROM BEST AVAILABLE COPY

contract with several local goods and services establishments for up to a total of 100% of its requirement. If less than 100% of a department's requirement is contracted locally, then the rest is automatically purchased from Outside at the Outside price. Government contracts with BG and BS establishments are made by players; they enter into the commercial allocation process only in that they consume BG and BS capacity before the other BG-BS buyers select shopping locations and thus decrease a BG's or BS's remaining capacity. Sellers to government are assured of government purchases. The number of units which a department consumes is the sum of the operating needs of its facilities (number of levels times a fixed requirement per level) and its maintenance requirements. Both BG and BS allocation summary outputs have a table showing where government departments are buying BG and BS, how many units are consumed by each department, and the total income to the BG or BS establishment for those sales.

5. Terminal Allocation Output

Heavy industries, light industries, and business goods use terminals. Terminals represent major shipping and receiving points through which those businesses interact with the Outside system.

A business is assigned by the program to the terminal to which it has the least transportation cost. However, terminals have capacities, and a terminal's usage affects a business's perception of the transportation cost to get there. The allocation process is similar to the commercial process in that terminal users are assigned to terminals simultaneously and then reevaluate their choices in light of the new allocation. However, there is no Outside terminal. Since the only cost to a terminal user is the transportation cost, it uses the best terminal it can find, i.e., the one to which the transportation cost weighted by its usage is least. The user pays only the actual transportation cost.

The terminal output lists the location of each terminal user, the type of economic activity, and the number of terminal capacity units consumed by the user. It also shows, for each terminal, the terminal's code number, its location (terminals are located at intersections), and its development level. The capacity of a level one terminal is shown on the Master Table. A terminal's capacity is its development level times the capacity of a level one terminal.

The terminal output also includes a map showing the geographic distribution of terminal users and terminals. Each parcel on the map contains a single digit, which, if non-zero, is the code number of the terminal which the economic activity on that parcel is using. Terminals are identified by their single digit codes, are located at intersections, and are surrounded by asterisks.

Figure 4.6

TERMINAL DEMAND AND SUPPLY TABLE

CUSTOMERS

LOCATIONS	LAND USE	REQUIREMENTS
9626	CR	3000
9428	MF	2000
9828	TE	2000
9630	PA	3000
9830	BG	1139
9432	FO	3000
9632	MP	6000

TERMINALS

NUMBER	LOCATION	LEVEL
1	9531	2

Figure 4.7

```
TERMINAL ALLOCATION MAP

      70  72  74  76  78  80  82  84  86  88  90  92  94  96  98 100 102 104 106 108 110 112 114
  12   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  12
  14   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  14
  16   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  16
  18   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  18
  20   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  20
  22   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  22
  24   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  24
  26   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  26
  28   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   0   0   0   0   0   0   0   0  28
  30   0   0   0   0   0   0   0   0   0   0   0   0   0   1   1   0   0   0   0   0   0   0   0  30
                                                        *1*                         *2*
  32   0   0   0   0   0   0   0   0   0   0   0   0   1   1   0   0   0   0   0   0   0   0   0  32
  34   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  34
  36   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  36
  38   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  38
  40   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  40
  42   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  42
  44   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  44
  46   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  46
  48   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  48
  50   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  50
  52   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  52
      70  72  74  76  78  80  82  84  86  88  90  92  94  96  98 100 102 104 106 108 110 112 114
```

E. SOCIAL SECTOR DETAILED OUTPUT

1. Dollar Value of Time

The social sector has four types of resources: time, voting power, money, and the power to boycott. The first two are unique to this sector, but it is through time allocation that social decision-makers can increase their voting strength. Time can be allocated to extra work, adult education, politics and recreation. Time is not specifically allocated to transportation to full-time work, but transportation makes the first claim on allocatible time; it decreases time available before time allocated to any other activities is considered by the program. The more time which a P1 spends travelling to work, the less time it has to spend in other more personally useful activities. A decision maker or the director can affect the amount of time which P1's spend travelling through the decision to specify the dollar value of a time unit travelling.

The computer assigns all population units to modes of transportation to and from work on the basis of least cost. Least cost includes transportation charges (which differ according to mode of transportation, type of road and amount of congestion) as well as the dollar value of time spent traveling. The social decision-maker or director is able to specify the dollar value of one time unit consumed traveling to and from work for each of the classes. As the dollar value of a time unit spent traveling increases, there is a greater chance that the computer will assign a more expensive but quicker mode of transportation to work (i.e., via automobile or rapid rail rather than bus). The following example will demonstrate how the computer considers the dollar value of time.

Assume that the tranpsortation dollar costs for one worker is $150 per year to get to work by bus and $230 to get to work by auto. It also requires an extra 4 time units to travel by bus instead of auto.

If the dollar value of time for that population unit was set at $40 then $160 (4 x $40) would be added to the bus cost to arrive at a total cost of $310 to get to work by bus. To take an auto it costs $320 (no extra time units consumed). Therefore, the computer would assign the population unit the BUS mode to travel to work (since $310 is less than $320).

In the same case, suppose the dollar value of time was set to $50. Then the total bus cost would be $150 plus 4 time units times $50 (dollar value) or $350. Auto

Figure - 5.1

```
****************************************************************
          TWOCITY
   DOLLAR VALUE OF TIME          JURISDICTION 1          ROUND  2
****************************************************************


                      SOCIO-ECONOMIC CLASS

              TEAM        HIGH    MIDDLE      LOW


               AA          20        15        10

               BB          10         8         6

               CC          47        44        38

               DD          54        41        37

               EE          52        49        36

               FF          59        32         8

               GG          57        43        34
```

would cost only $320. Therefore, the computer would assign these population units the auto mode to work (since $320 is less than $350).

A worker pays only the actual dollar cost to get to work. The dollar value of time is used for route and mode allocation purposes only. The dollar value of time represents the worth of a time unit being spent in transportation relative to the time unit being spent in other activities.

2. Social Decision-Maker Detailed Output

This output shows the characteristics and financial status of the Pl's controlled by a social decision-maker in each jurisdiction, in each class on each parcel. The characteristics and financial status of the Pl's in the same class on the same parcel are averages. They can differ only in their employment locations and salaries earned. For all other purposes, the model uses averages for the whole group.

The output contains one column for each parcel.

a. Location and Number of Pl's

The first two rows identify the residence location and number of Pl's in the class living there.

b. Education Level

A Pl's educational level affects its chances of obtaining a job. The higher its educational level relative to educational levels of others seeking employment, the greater its chances of getting a higher paying job. A social decision-maker can increase his Pl's educational levels by allocating time to adult education. Adult education represents an investment of time and money resources to improve a worker's relative usefulness to an employer, whether the investment be in courses, reading, or skill and experience improvement.

Public (free) adult education can be provided only by a jurisdiction's School Department. If the School Department of the jurisdiction in which a Pl resides does not provide an adult education program, the Pl cannot obtain free adult education. If the department does not provide enough adult education for the requests of the people in the jurisdiction, then all of the Pl's have only a portion of their requests satisfied. Pl's can also allocate time to private adult education, which they are assured of obtaining (if they have enough time units remaining after other time allocations) but which is relatively expensive.

c. Voter Registration Per Pl

Voter registration represents the maximum number of votes per Pl which the decision-maker can cast in an election. If voting is done through the computer, a portion of the registered voters turn out for an election.

Figure -5.2

```
**********************************************************
     TWOCITY
  SOCIAL DECISION MAKER GG      HIGH  SOCIO-ECONOMIC CLASS
**********************************************************

 LOCATION                                 8830      9030
 NUMBER OF P1'S                             13        23
 EDUCATION LEVEL                            90        81
 VOTER REGISTRATION PER P1                 216       216
 PREVIOUS SAVINGS PER P1                256269    130233
 PERCENT OF P1'S UNEMPLOYED                  0         4

 INCOME PER P1
     EMPLOYMENT(FULL)                  1312615   1292727
     EMPLOYMENT(PART)                   160384         0
     WELFARE                                 0    204000
     MISCELLANEOUS                         538         0

 EXPENDITURES PER P1
     RENT                               322000    276000
     TRANSPORTATION
        AUTO                             61551     72980
        BUS                                  0         0
        RAIL                                 0         0
     GOODS                              370000    370000
     SERVICES                           155200    155200
     SCHOOL (CHILDREN)                   39000     39000
     SCHOOL (ADULTS)                         0         0
     HEALTH                               8000      8000
     SALES TAX                           22894     22894
     INCOME TAX                         232500    195756
     AUTOMOBILE TAXES                      908      1406
     MISCELLANEOUS                           0         0

 SAVINGS PER P1                         260946    355491
 NEW BALANCE PER P1                     517215    485724


 TIME ALLOCATION PER P1

      TRANSPORTATION                         5        15
      ILLNESS                                3         3
      EXTRA JOB (25)                        10         0
      EDUCATION
         PUBLIC ( 0)                         0         0
         PRIVATE ( 0)                        0         0
      POLITICS (35)                         35        35
      RECREATION (10)                       10        10
      INVOLUNTARY                           37        37

 HEALTH INDEX                               25        25
 PERSONAL INDEX                             67       116
 NEIGHBORHOOD INDEX                        163       162
 ENVIRONMENTAL INDEX                       246       245
 QUALITY OF LIFE INDEX                     313       361
```

The decision-maker can increase the fixed minimum number of voters in a Pl by allocating time to political activity. The increase lasts for one round only, so a high registration can be maintained only if time is allocated to politics each round.

d. Previous Savings Per Pl

This is the average savings or deficit which a Pl has from previous years. It is added to the new savings (the current round's income less expenditures)and becomes the new balance, next round's previous savings.

e. Percent of Pl's Unemployed

This is the number of Pl's who were unable to obtain full-time jobs expressed as a percent of the number of Pl's of the class living on the parcel.

f. Average Income Per Pl

The population living on a parcel can derive income from up to four sources: full-time employment, part-time employment, welfare, and miscellaneous (cash transfers from other social or economic decision-makers or government departments). Welfare can be received only by those Pl's who are unemployed and is paid by the jurisdiction in which they reside, if that jurisdiction has a welfare program.

g. Average Expenditures Per Pl

Most personal expenditures are only partially affected, if at all, by social decision-makers. A level of each residence type has a fixed number of space units. A Pl of each class occupies a fixed number of space units. A residence owner sets a rent per space unit and a Pl pays rent on the number of space units which a Pl of its class occupies. Although the rent charged at a residence is set by its economic sector owner and the residents must pay that amount, rent is a factor in the allocation of people to housing in the migration process.

Transportation expenditures are incurred in the trip to work and to obtain goods and services. Auto, bus and rail may be used in the trip to work, but only auto may be used in commercial trips. All transportation routes and costs are calculated by the computer program. See the Employment Detail and Commercial Detail descriptions for more information on transportation costs.

The Commercial Detail description also explains Pl expenditures for goods and services, part of which is affected by the amount of time which a Pl spends in recreation.

A Pl pays for private education for its children if local schools are inadequate. Students are assigned to schools by the computer. Middle and high income families have certain criteria for the school in their district. If the school fails to meet these criteria, these students will be assigned by the computer to private schools at the expense of the population unit they represent. Those criteria are shown on the Master Tables. Students of the low socio-economic class go to the public school in their district regardless of the high and middle class criteria, unless their residence location is excluded from a district. The cost for private school varies by class and is shown on the Master Tables. A Pl pays for adult education if it has allocated time to private education. There is a fixed cost per time unit spent in adult education.

A Pl has a fixed annual health expenditure which varies with the Pl's class. In addition to that base amount, a Pl on a parcel having surface water or adjoining a parcel having surface water incurs a greater expenditure if there are any coliform bacteria in the water See the Master Tables for the precise costs.

There are three types of taxes which a Pl may have to pay: sales taxes, income taxes, and automobile taxes. There is a fixed state sales tax rate on all purchases of personal goods and services, regardless of whether the goods or services are purchased from local establishments or from the Outside. Local governments may alsc set tax rates on PG and PS purchases from commercial establishments within their own jurisdictions. That tax revenue accrues to the government of the seller's jurisdiction.

There are fixed federal-state income tax rates on all Pl's total full-time and part-time gross income. Local governments may also tax the gross income of the Pl's living in their jurisdictions and/or working in their jurisdictions. The tax revenue goes to the account of the jurisdiction levying the tax.

There are no fixed automobile taxes. Local governments may tax total automobile expenditures to get to full-time and part-time work by PL's living in their jurisdictions and/or working in their jurisdictions.

Miscellaneous expenditures are cash transfers made by the social decision-maker to other social or economic decision-makers or government departments.

h. Time Allocation

As mentioned above, social decision-makers allocate time for their Pl's to spend in extra work, adult education, politics and recreation. There are 100 units of leisure time available to each Pl. Two types of time allocation are not set by a decision-maker: time in illness and time in transportation. The time units spent in those two categories are first deducted from a Pl's 100 available time units before any time is spent in other activities.

Transportation time is explained above. The number of time units which a Pl spends in illness is equal to one-tenth of the health index on its residence parcel. The health index is a function of the use index of the municipal services unit serving the parcel, the amount of overcrowding at the residence, and the amount of coliform bacteria in the surface water on the parcel or on adjoining parcels.

The computer program performs all of the actual time allocation process in response to decision-makers' time allocation requests. If, after time has been subtracted for illness and transportation, the Pl has any remaining time units, it may enter the part-time employment process. The amount of time spent in part-time work is subtracted from the remaining time units, and if any time units remain, the Pl may enter the adult education allocation process. Politics and recreation are processed last, in that order, and in the same fashion with regard to not exceeding the 100 allocatable time units.

All of the time which a Pl allocated to a specific activity but was unable to spend in that activity contributes to "involuntary time". If during the time allocation process a Pl uses up all of its 100 time units, no time may be spent in subsequent activities.

All of the allocated units in excess of 100 become involuntary time. There are two other sources of involuntary time. If a Pl cannot obtain all of the part-time work which it requests (due to there being a greater number of time units allocated to part-time work than there are part-time jobs) the portion of the allocated time which was unfilled adds to involuntary time. The other source of involuntary time is the portion of a public adult education request which cannot be met by local adult education programs.

Involuntary time and transportation time contributes to a Pl's personal index. Recreation time decreases the personal index.

A social decision-maker sets the dollar value of a time unit travelling for all of a class boardwide. The dollar value of time of the high-income people controlled by BB, for example, cannot be different for those PH controlled by BB in jurisdiction 1 than it is for BB's PH in jurisdiction 3. Social decision-makers can, however, allocate time by jurisdiction and even by parcel. A decision-maker's preferred time allocations appear in parentheses to the right of the row headings labelling the types of allocations. Any exceptions for the decision-maker's preference on individual parcels show the preferred allocations in parentheses next to the actual allocations for the parcel.

i. Indexes

The Social Detailed Output also lists the values of five indexes used in the migration process. See the description of Migration for details.

3. Social Decision-Maker Boycott Status Output

Social decision-makers can boycott working for specific employers, shopping at specific PG or PS establishments, or using either the bus or rail modes of transportation. A boycott is in effect for an entire round and is continued until a decision is submitted to stop the boycott. The boycott output has one row per boycott, showing the social decision-maker boycotting, the class boycotting, the function boycotted (work, shop, or use), the location boycotted (0 if the boycott is against working for a government department), the land use boycotted (0 if the boycott is against a government department), and the owner of the establishment being boycotted (department and jurisdiction if the boycott is against a government department).

Figure 5.3

```
************************************************************************
     TWOCITY
  SOCIAL DECISION MAKER GG   BOYCOTT STATUS OUTPUT            ROUND  2
************************************************************************


                BOYCOTTING                           BOYCOTTED
                ----------                           ---------
           CLASS OR
     TEAM  LAND USE    FUNCTION       LOCATION    LAND USE    OWNER
     ----  --------    --------       --------    --------    -----

      GG     HIGH        WORK                                  SC1
```

F. Economic Decision-Maker Detailed Output

Each of the economic teams receives statistics at the beginning of every round of play that summarize the cash flow for the previous year, a balance sheet showing net worth, loans made and received, new construction completed, boycotts in operation, undeveloped land holdings, and detail on all of its businesses. The team may use any of its resources to achieve whatever objectives it desires.

1. Financial Summary

a. Cash Flow Statement

A team's cash holdings can be used to purchase additional property, construct any of the types of economic sector land uses on property that it owns and which is properly zoned and served with utilities, construct any level or type of effluent treatment plant at a business which it owns, demolish any building it owns, pay off loans, grant a loan to another team, pay taxes on undeveloped land, or spend it in some miscellaneous way (cash transfer to another team and purchase of national stocks).

Additions to the new balance (i.e., cash) come from income derived by selling property, receiving payment from loans, receiving loans, earning net income from investments (developments and farms) in the local economy, receiving government subsidies, earning interest on savings,* and from miscellaneous sources (cash transfers from others and sale of national stocks).

If the team makes no decisions during a particular round, it is still charged interest and principal payments on loans and taxes on undeveloped land. The team also automatically receives loan payments, interest on savings, and net income. This latter figure, however, may be a negative number if the developments of a given team are doing poor business and their expenses exceed income.

---

*Interest earned on savings is 2.5 percent. The calculation of interest on savings is:

PCB = previous cash balance
N = total net income from businesses this round
E = total expenditures this round, except expenditures for business operation, which are already accounted for in N.
Interest = .025 (PCB + N - E).

Figure 6.9

```
*************************************************************
      TWOCITY
   FINANCIAL SUMMARY--ECONOMIC DECISION MAKER A        ROUND  2
*************************************************************

        CASH FLOW STATEMENT
        -------------------


          PREVIOUS CASH BALANCE                $       180000000.


             EXPENDITURE
                  PROPERTY PURCHASED           $            8080.
                  CONSTRUCTION                 $       256000000.
                  DEMOLITION                   $         9599999.
                  LOAN PAYMENTS                $         6191512.
                  NEW LOANS GRANTED            $               0.
                  UNDEV LAND TAXES             $         6640346.
                  MISCELLANEOUS                $        10000000.


             INCOME
                  PROPERTY SOLD                $           97000.
                  LOAN PAYMENTS RECEIVED       $         2757808.
                  LOANS RECEIVED               $               0.
                  TOTAL NET INCOME             $        53077792.
                  SUBSIDIES                    $               0.
                  INTEREST ON SAVINGS          $               0.
                  MISCELLANEOUS                $       800080000.


             NEW BALANCE                       $       747572736.


                  CONSERVATIVE INVESTMENTS        $                0.
                       INCLUDING A RETURN OF  $                  0.
                  SPECULATIVE INVESTMENTS         $                0.
                       INCLUDING A RETURN OF  $                  0.

          TOTAL ASSETS                         $      1488160256.
                  CASH                         $               0.
                  LOANS TO OTHERS              $         4999999.
                  INVESTMENTS IN OUTSIDE       $               0.
                  DEVELOPMENTS                 $       240000000.
                  LAND                         $       495587594.


          LIABILITIES (INDEBTEDNESS)           $        76074384.
          NET WORTH                            $      1412085760.


       NEW BORROWING CAPABILITY FROM OUTSIDE $      1114453504.
```

b. Investments

The second part of the Financial Summary output shows investments in the national economy. A team may invest as much cash as it wishes in either conservative or speculative national businesses. The national business cycle generates the year by year rate of return for conservative stocks and for speculative stocks. In upswings in the business cycle, the rate of return on speculative stocks will always be larger. The range for the rate of return on conservative stocks is narrow and centers on six percent whereas for speculative stocks the range is wide and it centers on about seven percent. In bad years, however, the return on speculative stocks could be very small or even negative. The return from national investments is automatically used to purchase additional stock. A team must "dis-invest" in order to have returns from national investments show up in the cash account.

c. Balance Sheet

A team's assets are comprised of cash on hand, loans to others, the value of investments in the national economy, and the value of developments and land. Developments are valued at their typical construction costs times their value ratio divided by 100. Thus, developments that are not maintained decrease in value over time. Land is valued at the market value.

A team's liabilities are the sum of the principal on all loans from others (indebtedness). Net worth is the difference between current assets and liabilities. Teams may borrow up to 80% of their total assets from national bankers. The amount which a team can borrow from outside is shown on the last line of this output. There are no limits on the amount of debt that teams may have among themselves.

2. Loan Statement

The loans that a team has with national bankers (outside = OU) and with other teams are shown in the loan statement. The loans received from other sources are listed and their annual payments summarized. The loans granted to other teams are listed after that. Note that the interest rate may vary by loan.

Loans between teams are made for any amount and at whatever interest rate is mutually agreeable. The

Figure 6.8

```
**********************************************************************
         TWOCITY
     LOAN STATEMENT--ECONOMIC DECISION MAKER A                  ROUND  2
**********************************************************************


                                INTEREST     REMAINING    ORIGINAL        ANNUAL
  BORROWER       LENDER         RATE         YEARS        PRINCIPAL       PAYMENT
  --------       ------         --------     ---------    ---------       -------

     A             OU              3.5          23        $  75000000     $  4550592

     A             G               6.2           1        $   3000000     $  1640920
                                                                          ---------
                                                              TOTAL       $  6191512


     E             A               6.8           1        $   5000000     $  2757908
                                                                          ---------
                                                              TOTAL       $  2757908
```

only conditions on a loan internal to the system is that the period be specified as either 2 or 25 years, and that the lending team have sufficient cash to cover the loan.

An economic team may also borrow money from the outside system for either a 2 or 25 year period. The interest rate is set by the national bankers who take into consideration the national business cycle. An economic team that has debts equalling 80% of its total assets may not receive any further loans from the outside system.

3. Land Summary

The Land Summary output shows the location by parcel coordinates of all land owned by a team. It also shows the assessed value of the entire parcel (assuming that 100% of the parcel is valued in the same proportion as the private part), the publicly owned part (percent developed and undeveloped), the undevelopable percent, the number of units of utility service available to that parcel, and the actual number of utility units that are used.

Teams may acquire land from other players at mutually agreeable terms or from the director on a bid submission basis. The director represents small farmers and outside land holders who will sell if the price is right. The game director controls the sale of Outside-owned land.

The cost of making land bids on Outside-owned properties is set at some percent of the bid amount, regardless of the bid's success or failure (See Economic Sector Master Tables).

4. New Construction Table

The new construction output shows for an economic decision-maker the location at which a new development or an additional level of development is taking place. It also shows the type of development, the old and new level, the location of 0-0 which denotes an outside system firm, the contract price, the rent per space unit (if a residence) or the salary by class (if an employer), the quality index (if housing) or the price per CU (it a store), and the contract status. "Completed" means that the development became operational at the beginning of the round just completed.

Figure 6.7

```
****************************************************************************************************************
  BLUECITY
            LAND SUMMARY--ECONOMIC DECISION MAKER  B                                                 ROUND  1
****************************************************************************************************************


                               PRIVATELY OWNED                      PUBLICLY OWNED
                          -------------------------------       -----------------------
               ASSESSED                          TAXES ON                                                      UTILITY   CAPACITY
LOCATION          VALUE   %UNDEVELOPED     UNDEV. LAND       %DEVELOPED   %UNDEVELOPED   %UNDEVELOPABLE   CAPACITY       USED
--------       --------   ------------     -----------       ----------   ------------   --------------   --------   --------


  88-22    $    650000              88     $     22800                8              4                0          0          0
  94-22    $   1800000              64     $     46000               20              4                0        100          4
  96-24    $   2250000              56     $     50400               20              0                0        100         52
  94-26    $   1750000               0     $         0               68              8                0        100          8
 100-26    $   1730000              44     $     30400               32              0                0        100         52
  92-28    $   1500000              56     $     33600               20             12                0        200         77
 100-28    $   1500000              36     $     21600               16              0                0        100         16
 104-28    $    250000             100     $     10000                0              0                0        100          0
 106-30    $    750000              84     $     25200               16              0                0        100          0
  82-32    $    900000              84     $     30400               16              0                0          0          0
  98-32    $   1830000              56     $     40800               24              0                0        200         71
  88-34    $   1050000               0     $         0               64              0                0        100         12
 108-34    $    400000             100     $     16000                0              0                0          0          0
```

FILMED FROM BEST AVAILABLE COPY

Figure 6.6

```
***************************************************************************************************
             C I T Y   M O D E L      S A M P L E   O U T P U T
                    NEW CONSTRUCTION TABLE   - TEAM D                                       ROUND  3
***************************************************************************************************

                                                                    RENT/PLI    QUALITY INDEX
            LAND     OLD      NEW      CONSTRUCTION        AGREED      OR            OR
LOCATION    USE     LEVEL    LEVEL       LOCATION          PRICE     SALARIES     PRICE/CU          STATUS

 100-30      RA       2        4          0- 0         $  1820000    $140000         40           COMPLETED
```

FILMED FROM BEST AVAILABLE COPY

5. Economic Boycott

Economic teams may boycott the purchase of goods or services from local BG, BS, PG, and/or PS establishments, and their businesses can be boycotted by the social sector as a place to work or shop. Boycotts have effect for the full round, and they continue in operation for succeeding rounds unless terminated by a decision input on the part of the boycotting team. The boycott output shows the team boycotting, the income class or land use that is carrying out the boycott, and the function being boycotted (work or shop). The boycott output also shows the location and land use being boycotted, and the team owning the boycotted business.

Thus, boycott information appears as part of an economic decision-maker's output if he is boycotting and/or if he is being boycotted.

6. Farm Output

The farm output shows for each farm the farm code number, the type of farm, the number of parcels comprising the farm, the total number of percents of parcels comprising the farm, the farm's fertilizer level, the normal income per 1% of that farm (at fertilizer level zero and before local property taxes are deducted), the multiplier on normal income for each of the three other possible fertilizer levels, the actual income per 1% of that farm (before taxes), the total local property tax paid, and the total net income earned from the farm.

An economic decision-maker can make two types of decisions regarding farms: 1) set the fertilizer level at each farm; and 2) sell land on farm parcels. The higher the fertilizer level at a farm, the higher the actual net income before taxes and the greater the amount of pollution in the farm's runoff. A farm owner can either sell all of the farmland on a farm parcel to another economic decision-maker (in which case the parcel ceases to be classified as a farm) or sell part of the parcel to a government department.

The farm code number and farm type are fixed at the beginning of a game. They cannot be changed. The number of parcels and percents of parcels comprising a farm can be decreased but not increased by the farm owner. The normal income before taxes per 1% of a farm is also fixed at the start of a game. That income is multiplied by the multiplier

Figure 6.5

```
**********************************************************************
       TWOCITY
  ECONOMIC DECISION MAKER A    BOYCOTT STATUS OUTPUT          ROUND  2
**********************************************************************


                   BOYCOTTING                          BOYCOTTED
                   ----------                          ---------
               CLASS OR
        TEAM   LAND USE    FUNCTION          LOCATION   LAND USE    OWNER
        ----   --------    --------          --------   --------    -----

         A     MF            SHOP              9830        BG         C

         A     FO            SHOP              9830        BG         C
```

Figure 6.1

```
****************************************************************************************************************
                          TWOCITY
                      ECONOMIC DECISION-MAKER A    FARM OUTPUT                                                ROUND  2
****************************************************************************************************************

 FARM                NUMBER     NUMBER                 NORMAL INCOME   INCOME MULTIPLIER    ACTUAL INCOME
 CODE      FARM        OF         OF      FERTILIZER   BEFORE TAXES    FERTILIZER LEVEL:    BEFORE TAXES    TOTAL LAND      TOTAL
NUMBER     TYPE     PARCELS    PERCENTS     LEVEL      (PER 1% UNIT)    1     2     3       (PER 1% UNIT)    TAX PAID    NET INCOME
------     ----     -------    --------   ----------   -------------   ----- ----- -----    -------------   ----------   ----------

   1        F1         6         504          3             1000       1.07  1.12  1.20          1199           12094        592705
   2        F2         6         564          1             1000       1.08  1.16  1.25          1079           12182        596937
   3        F3         3         300          3             1000       1.05  1.09  1.15          1149            6899        338101
```

associated with the farm's fertilizer level to yield the actual income before taxes. The assessed value of farm parcels and property tax rates are set by the local government. The actual income before taxes is multiplied by the number of percents in the farm and the total land tax paid is subtracted from that result to yield the total net income.

7. Residence Detail

The Residence Output shows the location, type and level of each residential complex owned by a team. All residences in the model are described as rental units, although the rent on single family housing could be viewed as a form of mortgage payment. Although the construction and operation of housing is a player decision, the process that moves population units into housing is performed by the computer and is affected by player decisions in the economic and governmental sectors.

The economic decision-maker directly controls the rent of housing and its quality index (by changing the maintenance level). Government decision-makers affect the quality of municipal services and schools serving each residence and the tax rate and welfare rate for the jurisdiction containing each residence. Both government and economic decision-makers affect the water quality on a parcel. All of these factors are taken into consideration by the computer when assigning population units to available housing.

a. The Quality Index and Maintenance Level

The quality index of a residence is a measure of the present value of a development to the best possible value which a residence can have. The Social Sector Master Table shows that PH's require a quality index of at least 70, PM's a value of 40, and PL's a value of 20. This does not mean, however, that all Pl's of a given class automatically move out of housing when the quality index falls below the minimum value. They just won't move in, and they tend to move out because of increased dissatisfaction.

The quality index declines each year in response to time, the quality of local municipal services, increased fire damage due to insufficient water supply, and damage due to floods, unless maintenance is performed on the residence. The maintenance level indicates the lowest level the owner of the residence will allow the quality index to fall before incurring maintenance expenses. The quality index can be raised above its present level by the player inputting a main-

Figure 6.2

```
***********************************************************************
  TWOCITY
 ECONOMIC DECISION MAKER F   RESIDENCE OUTPUT              ROUND  2
***********************************************************************


       LOCATION                            9232          8634
       TYPE AND LEVEL                      RC 1          RA 4
       QUALITY INDEX                         80            75
       MAINTENANCE LEVEL                     80            75
       MS DISTRICT                            1             1
       UTILITY DISTRICT                       1             1

       DEPRECIATION (%)
            MS                              1.0           1.0
            FIRE                            0.0           0.0
            FLOOD                           0.0           0.0

       WATER CONSUMPTION (MGD)
            MUNICIPAL                      0.96          0.39
            OUTSIDE                        0.0           0.0

       OCCUPANTS                        8M 12H        1M  4H
       PERCENT OCCUPANCY                     69           117
       RENT/SPACE UNIT                   153000        154000

        INCOME
            RENT                        5304000       1437333

        EXPENDITURES
            MAINTENANCE                 1238000        118800
            UTILITIES                   1134900        155200
            WATER                        155520         34390
            PROPERTY TAXES               512244         74368
            INCOME TAXES                 875000        309750
            SALES TAXES                   54010          5186

       NET INCOME                       1334326        739649

       RATE OF RETURN                      5.93         21.13

       ENVIRONMENTAL INDEXES
           LOW INCOME                       332           268
           MIDDLE INCOME                    306           246
           HIGH INCOME                      310           248
```

tenance level that is higher than the quality index. The quality index may not be raised more than 20 points above the lowest level it has ever reached.

b. MS District

As was mentioned above, the quality of the municipal services (as measured by the MS use index) serving a residence has an effect on the attractiveness of that residence to potential occupants and on the rate of depreciation (decline in quality index) for that residence. The residence output shows the code number of the municipal service unit that serves each residence. The use index of each MS district is shown on the Municipal Services Report and on the Municipal Services Map. An MS use index value of 101 or more indicates overcapacity and means that the municipal services supplied are less than adequate. As the MS use index increases above 101, the residences served by that MS building become less and less attractive to P1's and the residences also depreciate at a faster and faster rate. For example, a use index of 150 is twice as bad as a use index of 125 and five times as bad as a use index of 110.

c. Utility District

Utility districts provide water and sewer services in addition to other utilities. If a district provides an insufficient amount of water for its users' needs, the fire protection afforded those users is inadequate. That inadequacy is reflected in an increased depreciation for all economic activities in the district. A water shortage can occur for any of the following reasons: 1) the intake water quality is 9 and therefore untreatable; 2) there is insufficient water for all of the users' needs; or 3) the district's intake treatment plant has the capacity to treat less water than its users need.

The residence output shows the code number of the utility district serving each residence parcel.

d. Depreciation

A residence has a normal annual depreciation, depending on its type (see Master Tables for depreciation rates). As mentioned above, it can also depreciate due to inadequate municipal services and/or inadequate fire protection. Another factor in depreciation is flooding. The director specifies when floods occur and a general degree of flooding. The degree of damage to the economic activity on a particular parcel is influenced by three additional factors: 1) the type of activity; 2) the river basin dam priorities; and 3) the likelihood of the parcel being affected by a flood. This last factor is called the parcel's flood susceptibility and can be found on the River Basin Flood Plain Map. A parcel having zero flood susceptibility is never affected by floods; a parcel having a susceptibility of three is among the most affected parcels. The parameters for the other factors in depreciation can be found on the Master Tables.

The amount of depreciation due to MS, fire, and flood is printed in percent of the activity's original value, assumed to be 100%.

e. Water Consumption

A residence normally receives all of its required water from a municipal source (its utility district). However, there are two exceptions: 1) when the utility district provides insufficient water for its users' needs (see c. above); and 2) when a residence is served by private utilities. Type RA residences can be constructed without having utility service. It is assumed that they have wells and septic tanks. They do pay an expense for water, but that amount is paid to the Outside and is lower than the normal Outside price for water. A residence supplied by a municipal water source receives water from Outside only when the local supply is inadequate. When such occurs, each residence receives an amount of water proportionate to its needs. For example if the needs of all of the water users in a utility totaled to 24 MGD and the district was only able to supply 16 MGD (67%), a residence needing 3 MGD would receive 2 MGD from the district (67%).

The amount of water required by a residence is a function of the residence type and class of occupants. In general, a high-income P1 uses more water than a low-income P1, and an RA dweller uses more water than an RC dweller. See the Master Tables for specific water requirements by class and residence type.

The residence output shows the amount of water obtained from municipal and Outside sources.

f. Occupants, Percent Occupancy, and Rent/Space Unit

The residence output shows the number of P1's of each class that occupy every residence. PH's and PL's may never live together on the same residence parcel. The percent of occupancy is determined by taking the number of P1's by class, multiplying times their residence space consumption index (Social Sector Master Table), and taking this as a ratio of the total space units in the residence.

For example, assume an RA3 has one PH and two PM's occupying it. The PH has a space consumption index of 2 and the two PM's together a space consumption index of 2.66 (2 x 1.33). Thus, there are 4.66 space units being occupied from an RA3 that has 6,00 space units of capacity. The occupancy rate is therefore 4.66/6 = .78, or the building is 78 percent occupied.

Rents are always specified in terms of the rent paid per space unit. A PM pays 1.33 times the per space unit rent, and a PH pays twice as much.

g. Income

The income earned by a residential unit is equal to the rent per space unit times the total number of space units occupied. In the above example, 4.66 space units were occupied; therefore, at a rent of $150,000 per space unit the rental income would be $699,000.

Income earned from a residence is independent of which classes occupy it; income is directly related to the percent which a residence is occupied and the rent being charged. The following example illustrates that point.

Income Earned from Housing Occupied by the Three Income Classes

Assume: Housing is an RA2
Rent specified is $150,000/space unit

Class	Relative Space Units Consumed	Number of Pl's Occupying an RA2 (2X Relative Space Units	Rent Paid Relative	Rent Paid Factor (Pl's x Rent Paid Relative)	Rent Paid (Rent Paid Factor x Rent Charges)
PH	1.0	2	2.00	4	$600,000
PM	1.5	3	1.33	4	$600,000
PL	2.0	4	1.00	4	$600,000

h. Expenditures

The owners of residences incur expenditures for maintenance, utilities, water, property taxes, income taxes, and sales taxes. A residence's maintenance expenditure is the sum of its expenditures for personal goods and personal services. The number of consumption units required for maintenance is a function of the total percent depreciation, the level of the residence, and the number of PG and PS units required for each percent depreciation. The number of units of PG and PS required for each percent depreciaiton is given on the Master Tables. The normal percent depreciation is also on the Master Tables, and depreciation due to other factors is on the residence output. Suppose that the RA3 mentioned above has a normal depreciation of 1% and has 2.5% more depreciation due to the other factors. Total depreciation: 3.5%. Suppose also that RA requires .7 PG units and .3 PS units per 1% depreciation. Assume that the residence owner has set a maintenance level which offsets that depreciation. The residence's PG consumption is: 3.5 x .7 x 3 = 7.35, or 7 PG units. Its PS consumption is: 3.5 x .3 x 3 = 3.15, or 3 PS units. The actual price paid per consumption unit depends on where the residence purchases PG and PS. That can be determined by examining the Commercial Detail Output.

The expenditure for utilities depends upon the number of utility units consumed by type and level of residence (see the Economic Master Table) and the cost per unit of utility service as established by the Utility Department. If the cost of utility service were $10,000 per unit, and an RA3 consumed 12 units per year, its utility cost would be $120,000.

Although P1's consume water, residence owners pay for the water. Local water prices per million gallons consumed in a year are set by the Utility Department for each economic activity. The prices for residences are set by class and by residence type. The residence owner pays the local price for that amount of water which is obtained from the Utility Department and pays the Outside price for the amount not supplied by the Utility Department (see Master Tables for Outside prices).

The pricing is relatively straightforward. For example, suppose an RA3 houses 2 PH and 1PM. Assume the Master Table shows that, in RA housing, a PH requires .08 MGD and consumes 29 MG in a year, and a PM requires .07 MGD and consumes 25 MG in a year. Suppose the total amount of water required by the water users in the utility district is 24 MGD but the district can supply only 16 MGD (67%). The residence output would show .15 MGD obtained from the municipal source (16/24 x (.08 + .08 + .07)) and .08MGD from Outside (.08 + .08 + .07 - .15). The total amount obtained from both sources equals the total amount required by the residence.

Whereas the daily requirement is used for determining local water sufficiency, the billing is done on an annual basis in proportion to the amount obtained from each source daily. Suppose the local price per MG for PH in RA is $350. Let the Outside price, which is always the same for all water users, be $700 per MG. Then the residence owner's water expenditure for Outside water is;

8/24 x (29 + 29 +25) x $700 = 19,366

The proportion purchased daily from outside is multiplied by the total annual requirement and the Outside cost per MG.

The Owner's payment to the local Utility Department is:

16/24 x (29 + 29) x $450 + 16/24 x 25 x $350 =
$8700 + 5833 = $14,533

Residences pay property tax on the assessed value of the building and the land occupied by the building. The Assessment Department has control over land and building assessments and the Chairman and Council have control over the tax rates which are applied to the assessed value.

Residences pay income taxes on the same basis as all other economic businesses -- a state tax of 5% on net income and a federal tax of 22% on the first $25,000 of net income before taxes and of 48% on the rest of net income and after state income taxes.

Residences pay sales taxes on the purchases from PG and PS for maintenance. The fixed state sales tax is 3% of PG and PS purchases and the local sales tax is whatever rate has been determined by the local sales tax authorities. Sales taxes accrue to the jurisdiction of the commercial establishment and not to the jurisdiction of the residence. State sales taxes are paid on purchases from the outside system as well as on local purchases.

i. Net Income

The final net income for residences is determined by subtracting all of the listed expenditures from the income derived through rents.

j. Rate of Return

The rate of return is printed for each business as a percent, expressing the ratio of the business's net income to its current value. Current value is the original value of the building times its value ratio (or quality index, in the case of a residence) divided by 100, plus the market value of the land consumed by the building.

k. Environmental Indexes

Residences are filled by P1's in the order of lowest environmental indexes first. The characteristics which contribute to a parcel's environmental index are: quality of the school serving the parcel, quality of the MS serving the parcel, residence quality, residence rent, local tax rates, local welfare payments, and the parcel's pollution index. Some of these factors are weighted differently by each class, so there is one index for each class for each parcel. The lower a parcel's environmental index for a class in relation to other parcels' environmental indexes for the class, the more desirable the parcel to migrating population units.

For the exact value of each factor in a parcel's environmental indexes, see the section of the migration output entitled "Environmental Indexes".

8. Basic Industry Detailed Output

The basic industry output shows the location and type of each basic industry owned by a team. A basic industry produces units of output that are sold at national markets and at per unit prices that are determined by the computer-generated national business cycle. Owners of basic industry should consult the section of the Demographic and Economic Statistics that shows the status of the national business cycle.

a. Constructed Level and Operating Level

Of all businesses represented in the model, basic industries alone may decrease their level of operations without demolishing a portion of their buildings. An industry's constructed level is the maximum level at which it may operate. It is effectively a physical restriction on the amount which can be produced. The operating level is the current level at which it is specified to function. The constructed level is considered only when land consumption, maintenance and taxes on the development are calculated. For all other purposes, a business's operating level is the only level considered.

b. Value Ratio and Maintenance Level

The quality of plant and equipment for businesses is represented by the value ratio. The value ratio is the ratio of present value to original value. Business facilities depreciate every year in response to time ("normal" depreciation), MS service quality, adequacy of local water for fire protection, and occasionally, floods. The Economic Master Table shows the annual percent depreciation caused by time, MS quality, and water supply for fire protection. Businesses may overcome this depreciation effect by setting their maintenance levels at points below which they do not want the value ratios to fall. For example, if a maintenance level is set at 100, then that business will make maintenance expenditures every year to keep the building in "like new" shape. The value ratio of a business may be raised above its present value (if less than 100) by inputting a maintenance level that is higher than the value ratio.

c. MS District

The value ratio of basic industry is lowered by poor municipal services as measured by an MS use index in excess of 100. Basic industry output shows the code number of the municipal service unit which serves the basic industry. MS use indexes are shown on the Municipal Services Department

Figure 6.3

```
*******************************************************
     TWOCITY
   ECONOMIC DECISION MAKER A    BASIC INDUSTRY OUTPUT
*******************************************************

        LOCATION                               9632
        CONSTRUCTED LEVEL                      MP 1
        OPERATING LEVEL                        MP 1
        VALUE RATIO                             100
        MAINTENANCE LEVEL                       100
        MS DISTRICT                               0
        UTILITY DISTRICT                          2
        DEPRECIATION (%)
            MS                                  2.9
            FIRE                                3.3
            FLOOD                               0.0
            WATER QUALITY                       0.0
        WATER CONSUMPTION (MGD)
            NORMAL SOURCE                    225.00
            OUTSIDE                             0.0
        PERCENT WATER RECYCLED                    0
        EFFLUENT TREATMENT
            TYPE AND LEVEL                     ST 1
        SALARY (PER WORKER IN 100'S
            HIGH                                110
            MIDDLE                               43
            LOW                                  29
        EMPLOYEES
          FULL TIME (IN P1'S)
            HIGH                                 19
            MIDDLE                               18
            LOW                                  18
          PART TIME (IN UNITS)
            HIGH                                 80
            MIDDLE                              160
            LOW                                 320
        EMPLOYMENT EFFECT                      1000
        UNITS PRODUCED                         1000
        PRICE/UNIT OUTPUT                    188300
        INCOME
            SALES(PRIVATE)                188300000
        EXPENDITURES
            GOODS                          18200000
            SERVICES                        3500000
            MAINTENANCE                    17000000
            UTILITIES                        770000
            WATER
              RECYCLING                           0
              INTAKE PROCESS               17550000
              OUTFLOW TREATMENT                   0
              MUNICIPAL SUPPLY                    0
            TRANSPORTATION                 12037497
            SALARIES                       52920000
            PROPERTY TAXES                  3608800
            SALES TAXES                     1161000
            INCOME TAXES                   22785000
        NET INCOME                         56317703

        RATE OF RETURN                        23.47
```

Report and on the Municipal Services Map. The contribution of the MS use index to value ratio decline is directly proportional to the amount by which the use index exceeds 100. For example, a use index of 150 has double the effect of a use index of 125 and five times the effect of a use index of 110.

d. Utility District

Utility districts provide water and sewer services in addition to other utilities. If a district provides an insufficient amount of water for its users' needs, the fire protection afforded those users is inadequate. That inadequacy is reflected in an increased depreciation for all economic activities in the district. A water shortage can occur for any of the following reasons: 1) the intake water quality is 9 and therefore untreatable; 2) there is insufficient water for all of the users' needs; or 3) the district's intake treatment plant has the capacity to treat less water than its users need.

e. Depreciation

A basic industry has a normal annual depreciation, depending on its type (see Master Tables for depreciation rates). It can also depreciate due to inadequate municipal services and/or inadequate fire protection. Another factor in depreciation is flooding. The director specifies when floods occur and a general degree of flooding. The degree of damage to the economic activity on a particular parcel is influenced by three additional factors: 1) the type of activity; 2) the river basin dam priorities; and 3) the likelihood of the parcel being affected by a flood. This last factor is called the parcel's flood susceptibility and can be found on the River Basin Flood Plain Map. A parcel having zero flood susceptibility is never affected by floods; a parcel having a susceptibility of three is among the most affected parcels. The parameters for the other factors in depreciation can be found on the Master Tables. The amount of depreciation due to MS, fire, and flood is printed in percent of the activity's original value, assumed to be 100%.

Basic industries which use surface water have an additional factor in depreciation: intake water quality. The maximum depreciation due to intake water quality is 1%, for water quality 9. The depreciation decreases as the water quality rating decreases, and there is no depreciation for quality 1 water.

f. Water Consumption and Recycling

Industries that use municipally-supplied water normally receive all of their required water from a local municipal source (the one within their utility district). However, there is one exception: when the utility district provides insufficient water for all of its users' needs. An industry supplied by a municipal water source receives water from Outside only when the local supply is inadequate. When such occurs, each industry receives an amount of water proportionate to its needs. For example if the needs of all of the water users in a utility totaled to 24 MGD and the district was only able to supply 16 MGD (67%), an industry needing 12 MGD would receive 8 MGD from the district (67% of its needs).

The only businesses which do not use municipal water are those basic industries which use surface water directly. There are two cases in which such a business would not obtain all of its water requirement from the surface water: 1) the total amount attempted removed from the surface water by itself and municipal intake points on its parcel was greater than the amount of surface water on the parcel; or 2) the surface water quality was 9. In the first case, the business would receive an amount of the surface water proportionate to its requirement. In the second case, the industry would purchase all of its water requirement from the Outside.

Basic industries which use surface water can recycle up to 100% of their water. At a recycling level of 100% an industry requires half as much water as normal and has half as much effluent, although the amount of pollution in the effluent does not change.

g. Effluent Treatment

A basic industry which uses surface water can treat its effluent. A treatment plant can be one of four types: chlorination (CL), primary treatment (PT), secondary treatment (ST), or tertiary treatment (TT). Each of the four types removes a percent of each pollutant, chlorination removing the least and tertiary the most. A treatment plant has a fixed capacity which is a function of its level. Each level of a business's effluent treatment plant has the capacity to treat the effluent generated by one level of the business at a recycling level of zero. For example, a level two treatment plant can treat all of the effluent generated by a business operating at a level two with no recycling. The plant could handle all of the effluent of a business operating at a level four if it had 100% recycling. Any effluent in excess of treatment plant capacity is dumped untreated into the surface water.

h. Salary

All industries must hire employees in terms of whole population units in order to operate and earn income.

Employees' salaries are expressed in terms of wage per worker and not per Pl. Since the number of population units actually hired by an employer is determined by the employment process which takes into account location, transportation, educational level of workers, salary offered and supply of and demand for workers, it is important that employers take into consideration the local labor market situation when setting salary levels.

i. Employees and Employment Effect

The number of population units required for a level one development of all businesses is shown in the Economic Master Table. The number actually hired is shown on the detail business output. Full-time employees are shown in population units (Pl's) and part-time employees are shown in time units, where 80 time units is equivalent to a full-time job in terms of income earned for a Pl.

If a basic industry hires all of the employees it requires, the employment effect is 1000 per level of development. A value of less than 1000 means that either some of the full or some of the part-time employees required from some income class were not hired. It is useful to check the Employment Summary and the Part-time Employment Statistics if deficiency of employees exists. If a basic industry at level one hires only 80 percent of the Pl's it requires, then the employment effect is 800 (i.e., 1000 x .80).

j. Units Produced

The maximum units produced by a basic industry is 1000 per level. If the employment effect is less than 1000 and/or if the value ratio is less than 100 then the units produced will not be at a maximum. The units produced figure is obtained by multiplying the employment effect by the value ratio divided by 100. Thus, if the employment effect were 800 and the value ratio were 90, then the units produced would be 720 (i.e., 800 x .90).

k. Price Per Unit of Output and Income

The price per unit of output for basic industry is determined by the national business cycle price relative and the normal price per unit for the industry type. The actual price per unit of output is the normal price multiplied by the business cycle price relative. Income is the product of the price per unit and the units produced. All sales of basic industry output are to the national system. All output is sold and no inventories are accumulated.

1. Expenditures

Basic industry incurs expenses for business goods and business services. A fixed amount of BG and BS units are purchased by basic industry by type and level for normal operation. Basic industry also purchases BG and BS units in direct proportion to the amount of maintenance performed, and these expenditures are listed separately under the maintenance category.

The expenditure for utilities depends upon the number of utility units consumed by basic industry by type and level (see the Economic Master Table) and price per utility unit being charged by the Utility Department.

There are four types of basic industry expenditures related to water: recycling, intake treatment, outflow treatment, and payment for municipal (or Outside) water. A basic industry which uses municipal water can have only the last of the four expenditures. Local water prices per million gallons consumed in a year are set by the Utility Department for each economic activity. The prices for industries may be set by type. The industry pays the local price for that amount of water which is obtained from the Utility Department and pays the Outside price for the amount not supplied by the Utility Department (see Master Tables for Outside prices).

The pricing is relatively straightforward. For example, suppose an industry consumes 10 MG per day and 2500 MG per year. Suppose the total amount of water required by the water users in its utility district is 24 MGD but the district can supply only 16 MGD (67%). The industry output would show 6.7 MGD obtained from the municipal source and 3.3 MGD from the Outside. The total amount obtained from both sources equals the total daily amount required by the industry (10 MGD).

Whereas the daily requirement is used for determining local water sufficiency, the billing is done on an annual basis in proportion to the amount obtained from each source daily. Suppose the local price per MG for the industry is $300. Let the Outside price, which is always the same for all water users, be $700 per MG. Then the industry's water expenditure for Outside water is: $700 x 3.3 x 250 = $577,500. The proportion purchased daily from Outside is multiplied by the total annual requirement and the Outside cost per MG.

The industry's payment to the local Utility Department is: $300 x 6.7 x 250 = $502,500.

A basic industry which uses surface water can incur all four types of expenditures.. Recycling and outflow treatment costs are direct functions of the business owner's decisions. The owner can set a recycling level of 0 to 100. A business at 100% recycling requires half as much water as a business at recycling level zero. Likewise, it has half as much effluent. The cost to recycle a million gallons of water is given on the Master Table. Suppose a TA required 17 MGD and 4420 MGY for a level one without recycling. Suppose a TA2 has a recycle level of 60%, and the cost to recycle is $200 per million gallons. The TA's annual volume of recycling would be: 4420 MGD x 2 x (100-60)/200 = 1768 MG. The cost for recycling would be: $200/MG x 1768 MG = $353,600.

The business owner also decides what type and level of effluent treatment, if any, the business has. The operating cost of an effluent treatment plant varies by type of treatment and number of MG's treated in a year. Suppose the TA cited above had an ST1 effluent treatment plant and the treatment cost per MG for ST was $200. Since the ST1 can treat only the equivalent of the outflow from a level one business, its capacity would be 4420 MG in a year. The business has 7072 MG of effluent (4420 x 2 - 1768). It pays $200 x 4420, or $884,000 for effluent treatment. 2652 MG are dumped untreated.

Expenditures for intake treatment and Outside water (listed under MUNICIPAL SUPPLY) are automatically billed to the business. A business does not construct an intake treatment plant; it is assumed to treat all of its required water to a usable condition. Intake treatment costs are a function of the intake water quality, the type of business, the volume of water consumed. If the intake water quality of the TA cited above were 3, and if the cost to a TA to treat water quality 3 were $80 per MG, the TA's intake treatment cost would be: (4420 MG x 2 - 1768 MG) x $80/MG = $565,760.

There is no cost to treat water purchased from the Outside. If part of a business's water were obtained from the surface water and, due to a shortage of surface water, part were obtained from the Outside, then the business would have expenditures for both intake treatment and Outside supply. If the surface water quality were 9, the business would have only the latter expenditure.

Basic industry pays transportation to BG and BS if the industry purchases these from the local system. The transportation charges are based on the type and level of industry and the least cost distances along the various types of roads. All basic industries except NS also incur transportation costs to the terminal which represents the cost of shipping the units produced to national markets. The transportation costs to BG, BS and the terminal are independent of the number of units purchased or produced. The costs are solely a function of type of industry, level, distance travelled to destination and type of roads. Regardless of the distance travelled, an industry pays a base cost to travel to each of the three types of destinations. The total transportation cost (c) to a single destination is:

$$C = (U \times B) + [U \times B \times L \times (4 \times T - R)]$$

where U is the number of units consumed
and B is the base cost per unit consumed
and L is the length of a parcel side in miles
and T is the number of parcel sides traversed along the least cost route between origin and destination
and R is the sum of the road types traversed along parcel sides on the least cost route
U x B is the base cost which the industry must pay.

Suppose that the Master Table showed that a CR1 consumes 3000 terminal units and has a base cost of $500 per terminal unit consumed. Suppose also that there is only one terminal and a CR2 has no options on ways to travel: it must go four parcels on a type 2 road and two parcels on a type 3 road. Suppose that in the simulated region a parcel side is 2.5 miles long.

U = 3000 times 2, or 6000 terminal units consumed
B = $500
L = 2.5
T = 6, since six parcels are traversed
R = 14, for four parcels on type 2 and two parcels on type 3 (4 x 2 + 2 x 3 = 14)

The total transportation cost to terminal for the CR is:

$$6000 \times \$500 + 6000 \times \$500 \times 2.5 \times (4 \times 6 - 14) = \$3,000,000 + \$75,000,000 = \$78,000,000$$

Salary costs by class are determined by multiplying the salary per worker times the number of workers per P1 times the number of P1's hired.

Businesses pay property tax on the assessed value of the development and the land occupied by the development. The Assessment Department assesses the value of land and developments and the Chairman and Council determine the tax rates to be applied to the assessed values of developments and of land.

Businesses pay income taxes to the Federal and State governments using the rates shown in the Master Table.

Businesses pay sales taxes on the purchases from BG and BS. There is a fixed state sales tax of 3%. State sales taxes are paid on purchases from the Outside system as well as on local purchases.

m. Net Income and Rate of Return

Basic industry net income is obtained by subtracting all of the above expenditures from the gross income.

The rate of return is printed for each business as a percent, expressing the ratio of the business's net income to its current value. Current value is the original value of the building times its value ratio divided by 100, plus the market value of the land consumed by the building.

9. Commercial Establishment Detail

The computer output for commercial establishments is slightly different for business commercial (BG and BS) and for personal commercial (PG and PS). The major difference is that BG and BS always purchase their needed supplies from the outside system, whereas PG and PS are able to purchase their goods and services from local BG and BS establishments. The commercial output shows the location, type and level of development.

a. Value Ratio and Maintenance Level

The quality of plant and equipment for commercial establishments is represented by the value ratio. The value ratio is the ratio of present value to original value. Commercial establishments depreciate every year in response to time ("normal" depreciation), MS service quality, use by customers, adequacy of local water for fire protection, and occasionally floods. The Commercial Master Table shows the annual percent depreciation caused by time, MS quality, use, and water supply for fire protection. Businesses may overcome this depreciation effect by setting their maintenance levels at points below which they do not want the value ratios to fall. For example, if a maintenance level is set at 100, then that business will make maintenance expenditures every year to keep the building in "like new" shape. The value ratio of a business may be raised above its present value (if less than 100) by inputting a maintenance level that is higher than the value ratio.

b. MS District

The value ratio for commercial establishments is lowered by poor municipal services as measured by an MS use index in excess of 100. The computer output for commercial establishments shows the code number of the municipal service unit which serves the basic industry. MS use indexes are shown on the Municipal Services Department Report and on the Municipal Services Map. The contribution of the MS use index to value ratio decline is directly proportional to the amount by which the use index exceeds 100. For example, a use index of 150 has double the effect of a use index of 125 and five times the effect of a use index of 110.

c. Utility District

Utility districts provide water and sewer services in addition to other utilities. If a district provides an insufficient amount of water for its users' needs, the fire protection afforded those users is inadequate. That

Figure 6.4

```
**************************************************************************
    TWOCITY
  ECONOMIC DECISION MAKER F     COMMERCIAL OUTPUT                ROUND  2
**************************************************************************
                LOCATION                                   9230
                TYPE AND LEVEL                             PG 1
                VALUE RATIO                                  90
                MAINTENANCE LEVEL                            90
                MS DISTRICT                                   1
                UTILITY DISTRICT                              1
                DEPRECIATION (%)
                    MS                                      2.6
                    FIRE                                    0.0
                    FLOOD                                   0.0
                    USE                                     0.8
                WATER CONSUMPTION (MGD)
                    MUNICIPAL                              0.23
                    OUTSIDE                                0.0
                SALARY (PER WORKER IN 100'S)
                    HIGH                                    100
                    MIDDLE                                   50
                    LOW                                      25
                EMPLOYEES
                  FULL TIME (IN P1'S)
                    HIGH                                      8
                    MIDDLE                                   13
                    LOW                                      18
                  PART TIME (IN UNITS)
                    HIGH                                      0
                    MIDDLE                                   80
                    LOW                                     160
                EMPLOYMENT EFFECT                         14609
                CAPACITY USED                             13822
                EFFECTIVE CAPACITY                        13148
                PRICE/CU                                  10000


                INCOME
                    SALES(PRIVATE)                    138220000


                EXPENDITURES
                    GOODS                              66430000
                    SERVICES                           23500000
                    MAINTENANCE                         1800000
                    UTILITIES                            960300
                    WATER                                 32085
                    TRANSPORTATION                       720000
                    SALARIES                           30800000
                    PROPERTY TAXES                      1022508
                    SALES TAXES                         2751900
                    INCOME TAXES                        2738750
                NET INCOME                              7496542

                RATE OF RETURN                            27.76
```

inadequacy is reflected in an increased depreciation for a. economic activities in the district. A water shortage can occur for any of the following reasons: 1) the intake water quality is 9 and therefore untreatable; 2) there is insufficient water for all of the users' needs; or 3) the district's intake treatment plant has the capacity to treat less water than its users need.

d. Depreciation

A commercial establishment has a normal annual depreciation, depending on its type (see Master Tables for depreciation rates). It can also depreciate due to inadequate municipal services, use in excess of its effective capacity, and/or inadequate fire protection. Another factor in depreciation is flooding. The director specifies when floods occur and a general degree of flooding. The degree of damage to the economic activity on a particular parcel is influenced by three additional factors: 1) the type of activity; 2) the river basin dam priorities; and 3) the likelihood of the parcel being affected by a flood. This last factor is called the parcel's flood susceptibility and can be found on the River Basin Flood Plain Map. A parcel having zero flood susceptibility is never affected by floods; a parcel having a susceptibility of three is among the most affected parcels. The parameters for the other factors in depreciation for commercial establishments can be found on the Commercial Master Tables. The amount of depreciation due to MS, fire, flood, and use is printed in percent of the activity's original value, assumed to be 100%.

e. Water Consumption

Commercial establishments use municipally-supplied water and they normally receive all of their required water from a local municipal source (the one within their utility district). However, there is one exception: when the utility district provides insufficient water for all of its users' needs. A commercial establishment supplied by a municipal water source receives water from Outside only when the local supply is inadequate. When such occurs, each business receives an amount of water proportionate to its needs. For example if the needs of all of the water users in a utility totaled to 24 MGD and the district was only able to supply 16 MGD (67%), a business needing 3 MGD would receive 2 MGD from the district (67% of its needs).

f. Salary

All businesses must hire employees in terms of whole population units in order to operate and produce shopping capacity. Employees' salaries are expressed in terms of wage per worker and not per P1. Since the number of population units actually hired by an employer is determined by the employment process which takes into account location, transportation, educational level of workers, salary offered and supply of and demand for workers, it is important that employers take into consideration the local labor market situation when setting salary levels.

g. Employees and Employment Effect

The number of population units required for a level one development of all commercial establishments is shown in the Commercial Master Table. The number actually hired by a commercial establishment is shown on the detailed computer output. Full-time employees are shown in population units (P1's) and part-time employees are shown in time units, where 80 time units is equivalent to a full-time job in terms of income earned for a P1.

If a commercial establishment hires all of the employees it requires, the employment effect is equal to the design capacity shown in the Commercial Master Table. A value of less than this design capacity means that either some of the full or some of the part-time employees required from some income class were not hired. It is useful to check the Employment Summary and the Part-time Employment Statistics if deficiency of employees exists. If a commercial establishment at a development level of one hires only 80 percent of the P1's it requires, then the employment effect is 80 percent of the design capacity.

h. Capacity Used and Effective Capacity

The effective capacity is calculated for commercial establishments by multiplying the employment effect times the value ratio divided by 100. The effective capacity indicates the number of capacity units (CU's) that the commercial establishment can supply to its customers without a strain on plant, equipment, and quality of service.

Capacity used is the number of consumption units that the commercial establishment actually sold to customers in the competitive local market as determined by the commercial assignment process. If the capacity used exceeds the effective capacity, then the commercial establishment undergoes a strain on its plant and equipment that is represented by increased depreciation of the physical facilities. BG and BS establishments may sign contracts with local government departments (Schools and Municipal Services) to automatically supply these departments with their needed goods and services. If these two government departments do not make a contract with a local firm, they will purchase from the outside system at greater than normal prices per unit. These government departments can specify a contract with up to three local BG and three local BS establishments. Greater detail on these contracts is given under the description of the government sector.

i. Price per Capacity Unit (CU)

Each commercial establishment sets its own price. Factors that must be taken into account when setting price are location in relation to potential workers, buyers and sellers; competitive establishments; local demand; boycotts; and the typical price. Typical prices are listed in the Economic Master Table.

The Commercial Process assigns customers to commercial establishments on the basis of least cost to the customer per consumption unit, including the customer's transportation cost to get to the commercial establishment. Customers also are given a bias to shop where they shopped the previous year and a bias against shopping at over-crowded establishments.

Owners of commercial establishments are encouraged to examine the commercial allocation summary output and the commercial maps to see which stores are serving which customers. A detailed description of this output can be found under the General Output Section.

j. Income

Sales to private customers and sales to public customers are separated for BG and BS, but not for PG and PS since the latter establishments sell to only the private sector. Income is the product of capacity used and price per CU.

k. Expenditures

BG and BS spend money for service charges which represent purchases from the outside system. PG and PS spend money for business goods and business services that represent the finished goods and services that they require in order to operate. In both cases, the dollar amount of expenditures for goods and services (service charges) is directly related to the number of capacity units sold. These relationships are shown in the Commercial Master Table.

Commercial establishments must pay annual maintenance if the value ratio is to be prevented from declining. BG and BS pay their maintenance to the outside system, whereas PG and PS purchase units of BG and BS for the purposes of maintenance. These relationships are also shown in the Commercial Master Table along with the factors that cause depreciation. Remember that overcrowding of commercial establishments causes the depreciation rate to increase.

Commercial establishments purchase utilities based upon type and level of development as indicated in the Commercial Master Table.

There is one type of commercial establishment expenditure for water: payment for municipal (or Outside) water. Local water prices per million gallons consumed in a year are set by the Utility Department for each economic activity. The prices for commercial establishments may be set by type of establishment. The business pays the local price for that amount of water which is obtained from the Utility Department and pays the Outside price for the amount not supplied by the Utility Department (see Outside System Master Tables for Outside prices).

The pricing is relatively straightforward. For example, suppose a business consumes 1.0 MG per day and 300 MG per year. Suppose the total amount of water required by the water users in its utility district is 24 MGD but the district can supply only 16 MGD (67%). The business output would show .67 MGD obtained from the municipal source and .33 MGD from the Outside. The total amount obtained from both sources equals the total daily amount required by the industry (1.0 MGD).

Whereas the daily requirement is used for determining local water sufficiency, the billing is done on an annual basis in proportion to the amount obtained from each source daily. Suppose the local price per MG for the commercial establishment is $300. Let the Outside price, which is always the same for all water users, be $700 per MG. Then the business's water expenditure for Outside water is: $700 x .33 x 300 = $70,000. The proportion purchased daily from Outside is multiplied by the total annual requirement and the Outside cost per MG. The business's payment to the local Utility Department is: $300 x .67 x 300 = $60,000.

PG and PS have transportation charges to BG and BS if they purchase locally, BG has transportation to terminal to purchase goods from the Outside system, and BS has no transportation charges. The transportation costs by type of road to the several destinations are given in the

Commercial Master Table. Transportation costs incurred by commercial businesses are dependent upon the number of units purchased. The costs are also dependent upon the type of buyer and seller, the distance travelled to the destination, and the type of roads. Regardless of the distance travelled, a business pays a base cost to travel to a destination. The total transportation cost (c) to a single destination is:

$$C = (U \times B) + [U \times B \times L \times (4 \times T - R)]$$

where U is the number of units consumed
  and B is the base cost per unit consumed
  and L is the length of a parcel side in miles
  and T is the number of parcel sides traversed along the least cost route between origin and destination
  and R is the sum of the road types traversed along parcel sides on the least cost route
U x B is the base cost which the business must pay.

Suppose that the commercial output showed that a BG 1 had a capacity used of 2000 and therefore consumed 2000 terminal units. Assume that the Commercial Master Table shows that it cost \$400 per HY 3 mile to travel to the terminal. Suppose also that there is only one terminal and the BG 2 has no options on ways to travel: it must go four parcels on a type 2 road and two parcels on a type 3 road. Suppose that in the simulated region a parcel side is 2.5 miles long.

U = 2000 terminal units consumed
B = \$400
L = 2.5
T = 6, since six parcels are traversed
R = 14, for four parcels on type 2 and two parcels on type 3 (4 x 2 + 2 x 3 = 14)

The total transportation cost to terminal for the BG is:

$$2000 \times \$400 + 2000 \times \$400 \times 2.5 \times (4 \times 6 - 14) = \$800{,}000 + 20{,}000{,}000 = \$20{,}800{,}000$$

Salary costs by class are determined by multiplying the salary per worker times the number of workers per P1 times the number of P1's hired.

Businesses pay property tax on the assessed value of the development and the land occupied by the development. The Assessment Department assesses the value of land and developments and the Chairman and Council determine the tax rates to be applied to the assessed values of developments and of land. Businesses pay income taxes to the

Federal and State governments using the rates shown in the Commercial Master Table. State income taxes apply to the net income figure before other taxes have been deducted.

Businesses pay sales taxes on the purchases of goods and services. There is a fixed state sales tax of 3%. State sales taxes are paid on purchases from the Outside system as well as on local purchases.

1. Net Income and Rate of Return

Business net income is obtained by subtracting all of the above expenditures from the gross income. Net income for commercial establishments can be very volatile because of the competitive aspect of the local market and the individual business's control over pricing.

The rate of return is printed for each business as a percent, expressing the ratio of the business's net income to its current value. Current value is the original value of the building times its value ratio divided by 100, plus the market value of the land consumed by the building.

G. GOVERNMENT SECTOR DETAILED OUTPUT

Chairman Output

The Chairman Output consists of three sections which summarize the revenues and expenditures of all departments and of the jurisdiction's government as a whole.

Chairman Department Finances

The first line of this output shows the welfare payment rate, which is set by the Chairman. The rest of the output summarizes the revenues and expenditures of each department in the Chairman's jurisdiction: Municipal Services, Schools, Highways, Planning and Zoning, Utilities, and Chairman. Bus and Rail are interjurisdictional and their finances do not appear on the Chairman's report.

The Chairman can grant appropriations to Municipal Services, Schools, Highways and Planning and Zoning. He can grant subsidies to Utilities, Bus and Rail, and he can transfer cash to any account.

Further detail on departments' accounts is included in the descriptions of their output.

Tax Summary

This output shows the revenue which the Chairman account receives from each type of local tax formally included in the model. Taxes constitute a major source of revenue for the operation of local government. There are four types of local taxes in the model: property, income, automobile, and sales. The Chairman specifies the rate at which these taxes are to be levied and the computer automatically collects the tax revenue. If the Chairman does not set tax rates for a given round, the computer collects taxes at the previous rate.

There are two types of property taxes: land and developments. Land tax is applied to all privately owned land. The tax paid is determined by multiplying the percent of a parcel privately owned times the assessed value of the parcel (set by the Assessment Department) times the land tax rate. Development tax is applied to economic land uses. The tax payment is determined by multiplying the assessed value of a development times the development tax rate.

Figure 8.18

CHAIRMAN DEPARTMENT FINANCES

```
WELFARE PAYMENT PER UNEMPLOYED WORKER IS 1600.

                              MUNICIPAL SERVICES
                              ------------------

          CAPITAL                                      CURRENT
          -------                                      -------

PREVIOUS CASH BALANCE                  0.   PREVIOUS CASH BALANCE            0.

REVENUES                                    REVENUES
    APPROPRIATIONS                     0.     APPROPRIATIONS          12000000.
    BONDING                            0.     FED/STATE AID             523250.
    MISC. INCOME                       0.     BONDING                 15870000.
                                              MISC. INCOME                   0.

                                 -------                               -------
TOTAL                                  0.   TOTAL                     28393250.

EXPENDITURES                                EXPENDITURES
    CONSTRUCTION                       0.     BOND PAYMENTS             312919.
    LAND PURCHASE                      0.     GOODS + SERVICES         2600000.
    MISCELLANEOUS                      0.     MISCELLANEOUS                  0.
                                              SALARIES                 4992000.
                                              WELFARE PAYMENTS        20480000.

                                 -------                               -------
TOTAL                                  0.   TOTAL                     28384919.

NEW CASH BALANCE                       0.   NEW CASH BALANCE              8331.

-------------------------------------------------------------------------------
-------------------------------------------------------------------------------

                                   SCHOOLS
                                   -------

          CAPITAL                                      CURRENT
          -------                                      -------

PREVIOUS CASH BALANCE                  0.   PREVIOUS CASH BALANCE            0.

REVENUES                                    REVENUES
    APPROPRIATIONS                     0.     APPROPRIATIONS          10000000.
    BONDING                            0.     FED/STATE AID            5399775.
    MISC. INCOME                       0.     BONDING                  2090000.
    FED/STATE AID                      0.     MISC. INCOME                   0.

                                 -------                               -------
TOTAL                                  0.   TOTAL                     17489775.

EXPENDITURES                                EXPENDITURES
    CONSTRUCTION                       0.     BOND PAYMENTS            1334623.
    LAND PURCHASE                      0.     GOODS + SERVICES         2860000.
    MISCELLANEOUS                      0.     MISCELLANEOUS                  0.
                                              SALARIES                10220000.
                                              ADULT EDUCATION          3075000.

                                 -------                               -------
TOTAL                                  0.   TOTAL                     17489623.

NEW CASH BALANCE                       0.   NEW CASH BALANCE               152.

-------------------------------------------------------------------------------
-------------------------------------------------------------------------------

                                   HIGHWAYS
                                   --------

          CAPITAL                                      CURRENT
          -------                                      -------

PREVIOUS CASH BALANCE                  0.   PREVIOUS CASH BALANCE            0.

REVENUES                                    REVENUES
    APPROPRIATIONS               3000000.     APPROPRIATIONS           1000000.
    BONDING                            0.     BONDING                   180000.
    MISC. INCOME                       0.     MISC. INCOME                   0.
    FED/STATE AID                      0.

                                 -------                               -------
TOTAL                            3000000.   TOTAL                      1180000.

EXPENDITURES                                EXPENDITURES
    ROAD CONSTRUCTION                  0.     MAINTENANCE               720588.
    TERM. CONSTRUCTION                 0.     BOND PAYMENTS             456881.
    LAND PURCHASE                      0.
    MISCELLANEOUS                      0.     MISCELLANEOUS                  0.

                                 -------                               -------
TOTAL                                  0.   TOTAL                      1177469.

NEW CASH BALANCE                 3000000.   NEW CASH BALANCE              2531.
```

FILMED FROM BEST AVAILABLE COPY

Figure 8.18 (Cont.)

```
                    PLANNING AND ZONING
                    -------------------

                         CAPITAL
                         -------

               PREVIOUS CASH BALANCE                  0.
               REVENUES
                   APPROPRIATIONS               3000000.
                   BONDING                            0.
                   MISC. INCOME                       0.

                                                 -------
               TOTAL                            3000000.

               EXPENDITURES
                   PUBLIC INSTITUTIONS                0.
                   LAND PURCHASE                      0.
                   BOND PAYMENTS                      0.
                   MISCELLANEOUS                      0.

                                                 -------
               TOTAL                                  0.

               NEW CASH BALANCE                 3000000.

------------------------------------------------------------------------
------------------------------------------------------------------------


                         UTILITIES
                         ---------

        CAPITAL                                   CURRENT
        -------                                   -------

PREVIOUS CASH BALANCE          0.    PREVIOUS CASH BALANCE           0.

REVENUES                             REVENUES
    SUBSIDIES                  0.      INCOME FROM USERS      29110000.
    BONDING                    0.      SUBSIDIES                     0.
    MISC. INCOME               0.      BONDING                       0.
                                       MISC. INCOME                  0.

                         -------                               -------
TOTAL                          0.    TOTAL                    29110000.

EXPENDITURES                         EXPENDITURES
    PLANT CONSTRUCTION         0.      OPERATING COSTS        19799998.
    EXTENSION OF SERVICE       0.      TAXES                         0.
    LAND PURCHASE              0.      BOND PAYMENTS           1189055.
    MISCELLANEOUS              0.      MISCELLANEOUS                 0.
    LINE CONSTRUCTION          0.
                         -------                               -------
TOTAL                          0.    TOTAL                    20989053.

NEW CASH BALANCE               0.    NEW CASH BALANCE       [illegible]

------------------------------------------------------------------------
------------------------------------------------------------------------


                    CHAIRMAN'S ACCOUNTING
                    ---------------------

                          CURRENT
                          -------

               PREVIOUS CASH BALANCE                  0.
               REVENUES
                 TAXES                          -6693701.
                 NEW BONDING                    35700000.
                 MISCELLANEOUS                        0.

                                                 -------
               TOTAL                            29006299.

               EXPENDITURES
                 APPROPRIATIONS                 29000000.
                 SUBSIDIES                            0.
                 BOND PAYMENTS                        0.
                 MISCELLANEOUS                        0.

                                                 -------
               TOTAL                            29000000.

               NEW CASH BALANCE                     6299.

------------------------------------------------------------------------
------------------------------------------------------------------------


                     OUTSTANDING BONDS
                     -----------------

  TYPE          ORIGINAL    REMAINING    INTEREST       ANNUAL
                PRINCIPAL     TERM         RATE         PAYMENT
  ----          ---------   ---------    --------       -------

CURRENT         35700000.      2           3.1          9684247.
```

FILMED FROM BEST AVAILABLE COPY

A political jurisdiction may tax the personal income of either the people who live there or the people who work there. A resident income tax is paid by a population unit and is determined by multiplying the resident income tax rate times gross wages of people who live in a jurisdiction. Employee income tax is determined by multiplying the employee income tax rate times gross income of the people who work in the jurisdiction.

Automobile taxes can also be levied by a particular jurisdiction on the people who live there and the people who work there. Automobile resident tax is determined by multiplying the automobile resident tax rate times the travel cost to work by automobile of the people who live in the jurisdiction. Automobile employee tax is determined by multiplying the automobile employee tax rate times the travel cost to work of the people who work in the jurisdiction.

Sales taxes are levied on all purchasers of personal goods and personal services. There are separate tax rates for goods and services. The tax is determined by multiplying the sales tax rate on goods/services in the jurisdiction in which the seller is located times the amount of purchase of goods/service at each seller.

Financial Summary

This output summarizes the cash flow which is itemized on the Chairman Department Finances output.

COMPUTER OUTPUT EXPLANATION FOR THE ASSESSMENT DEPARTMENT

Assessment Department Output

As in all roles, the Assessment Department not only interacts with all of the other users of the model in the Economic, Social, and Government Sectors but with the computer as well.

The computer output used by the Assessment Department exclusively can be broken up into two general types: tabular and maps.

Tabular Output

The tabular output for the Assessment Department of each jurisdiction shows the current assessment ratios for the jurisdiction as a whole and any exceptions to these jurisdiction-wide assessment ratios.

The first portion displays the overall assessment ratio for all properties in the jurisdiction. Assessment ratios may vary for land that is on developed parcels and land that is locally owned but on undeveloped parcels. Developments may be assessed by development type. Likewise each of the farm types may be assessed at different rates.

The second portion lists any exceptions to these jurisdiction-wide ratios. The parcel number is listed and the specific assessment ratio is given in percentage terms for developments (land use need not be specified since there is only one private land use allowed per parcel), non-farm land, and farm land. The Assessment Department may wish to make specific dollar assessments (instead of assessment rates) for particular parcels of land. These are the last three categories on the tabular output: building (developments), land (non-farm land) and farms.

Map Output

There are three maps of primary interest to the assessor. These maps supplement the printed matter discussed above and are used to plan the assessment strategy for the jurisdiction. The maps are: (1) Market Value Map, (2) Assessed Value Map, and (3) Farm Assessed and Market Value Map.

Other maps may also be of use to the Assessment Department. These include the Economic Status, Utility, and Planning and Zoning maps.

Figure 8.1

```
***********************************************************************
       TWOCITY
   ASSESSMENT REPORT             JURISDICTION 1           ROUND  2
***********************************************************************

           ASSESSMENT RATIOS  (PERCENT OF MARKET VALUE)
           ------------------------------------------

            LAND ON UNDEVELOPED PARCELS              50.0
            LAND ON DEVELOPED PARCELS                50.0



              BUSINESS TYPE:        RA               50.0
                                    RB               50.0
                                    RC               50.0
                                    LI               50.0
                                    HI               50.0
                                    NS               50.0
                                    CI               10.0
                                    BG               50.0
                                    BS               50.0
                                    PG               50.0
                                    PS               50.0
              FARM TYPE:            F1               15.0
                                    F2               15.0
                                    F3               15.0



           EXCEPTIONS TO JURISDICTION-WIDE RATIOS
           ------------------------------------
                          LOCATION    RATIO (%)
                          --------    ---------


            DEVELOPMENT:   NONE


            NON-FARM LAND: NONE


            FARM LAND:     NONE


            DOLLAR VALUE
             BUILDING:     NONE


            DOLLAR VALUE
             LAND:         NONE
```

Utility Department Output

The Utility Department is responsible for the provision of the utility and water and sewer services which economic activities require in order to operate. The department's utility operations are separate from its water and sewer operations but both are funded from the department's general budget.

Each utility plant has its own district, comprised of full parcels contiguous to the utility plant. A utility district is also a water district, which can contain one water intake treatment plant and one sewage treatment plant. When utility service is installed on a parcel, water and sewer service is also installed.

Utility plants, intake treatment plants, and outflow treatment plants are constructed in levels, each level having a fixed capacity of service. Outflow treatment plants are also constructed as certain types, each type having the ability to remove different amounts of each pollutant type. All of the plants require a fixed amount of land for each constructed level. When a level is demolished, the land becomes available for other Utility Department construction or sale to another owner.

The Utility Department output consists of a financial summary, a report on utility plants, treatment plants, water sampling stations, and miscellaneous other information of concern to the Department.

Utility Department Finances

All capital and current revenues and expenditures are summarized on this output. Capital expenditures are made in direct response to player decisions; current expenditures are made in response to policies set by players. All capital revenues and the current revenues of subsidies, bonding, and miscellaneous income are obtained in the manner described in the Introduction to the Government Sector. The Utility Department has two additional sources of current income: income from utility users and income from water users. For the most part, the two types of users are identical. However, some types of basic industries use surface water directly and do not require municipal water although they do require utilities.*

---

* One exception to this rule is the case of an RA with private utilities (well water, septic tanks, etc.). Such an RA does not drain municipally-provided utilities or water.

Figure 8.6

```
*******************************************************************************
                              TWOCITY
                                         UTILITY DEPARTMENT FINANCES
*******************************************************************************


                           FINANCIAL ACCOUNTING

     CAPITAL                                          CURRENT
PREVIOUS CASH BALANCE                   0.     PREVIOUS CASH BALANCE           6769.

REVENUES                                       REVENUES
    SUBSIDIES                    60000000.       SUBSIDIES                        0.
    BONDING                             0.       BONDING                    7580000.
    MISC. INCOME                270000000.       MISC. INCOME                     0.
                                                 UTILITY USERS             11310200.
                                                 WATER USERS                      0.


                                  -------                                   -------
TOTAL                           330000000.     TOTAL                       18890200.


EXPENDITURES                                   EXPENDITURES
    UTILITY PLANT CONSTR         30000000.       UTILITY OPERATION         15773330.
    TREATMENT PLANT CONSTR       15599999.       TREATMENT OPERATION        1347152.
    MISCELLANEOUS                       0.       SAMPLING STATIONS           700000.
    EXTENSION OF SERVICE                0.       MISCELLANEOUS                    0.
    LAND PURCHASE                  122000.       BOND PAYMENTS              1075191.


                                  -------                                   -------
TOTAL                            45721999.     TOTAL                       18895673.


NEW CASH BALANCE                284278001.     NEW CASH BALANCE                1296.
```

The Department sets the price which any economic activity must pay per utility unit consumed. That price does not vary with the type of economic activity consuming utilities. Each activity does consume a different number of utility units, but the price per unit consumed is the same for every utility user.

The Department also sets the water price per MG consumed, but the price set can vary by the type of economic activity, and, in the case of residences, by class. Utility users always obtain the utility service which they need; the only variable is the price set by the Utility Department. However, the Utility Department might not always be able to provide sufficient water for all of its users' needs, the reasons for which are explained below. A water shortage is relevant to current revenues because water users pay the Department for only the water which they actually obtain from the municipal system.

Capital expenditures are separated into five types: utility plant construction, treatment plant construction, extension of service, land purchase, and miscellaneous. The expenditures under utility plant construction also include utility plant demolition costs. The cost to construct or demolish each level of a utility plant are given on the Master Table. Treatment plant construction costs include the costs to construct and demolish levels of intake treatment plants and the costs to construct and demolish types and levels of effluent treatment plants. The costs for extension of utility service include extension of water and sewer service to those parcels receiving utilities for the first time. Once a parcel has utilities, it never needs more water and sewer service; if a parcel has any utility service of whatever level it has sufficient water and sewer service for any level of any economic activity. The land purchase expenditure category includes income from land sale. Both utility plants and treatment plants require land for construction. Miscellaneous capital expenditures are the total of all cash transfers made from the department's capital account.

There are five types of current expenditures: utility plant operation, treatment plant operation, sampling station operation, bond payments, and miscellaneous. The expenditure for utility plant operation is the total of the operating costs of all of the utility plants in the jurisdiction. Treatment plant operation is the total of the operating costs of all of the intake and outflow treatment plants in the jurisdiction. There is one fixed cost to operate each ambient (river quality) sampling station and another fixed cost to operate each point source (user effluent quality) sampling station. The total operating cost of all sampling stations in the jurisdiction appears as a single current expenditure. Payments on both current and capital bonds are made through the current account. Miscellaneous current expenditures are the total of all cash transfers made from the department's current account.

The new cash balances in both accounts remain in those accounts and are available for expenditure in the following round.

Water Department Reports

Four types of detailed information are shown on this output: intake treatment plant status, outflow (effluent) treatment plant status, municipal sampling station reports, and the water prices which have been set by the department.

The intake treatment plant table has one row per intake plant. Each intake treatment plant has a code number which is identical to the code number of the utility district in which it is located and which it serves. Both the plant code number and its coordinates are given here. An intake plant also has a level, which denotes its maximum capacity (in MGD) to treat water.

The water which is treated at an intake treatment plant may actually be obtained from surface water anywhere in the simulated region, although the water intake for a single utility district must all be from a single parcel having surface water. The coordinates of the parcel on which a district's intake point is located are in the fourth column. The fifth column shows the intake water quality. Intake water quality affects the cost which the department must pay in order to treat the water to drinking water quality. The worse the water, the greater the cost per MG to treat the water.

The total water requirement (in MGD) of all of the water users in the utility district is in the sixth column. The seventh column contains the total amount of water (in MGD) which the department was able to obtain from the surface water at its intake point. The amount obtained is never greater than the amount needed. There are three possible reasons that the amount obtained could be less than the amount needed: 1) the water quality on the parcel on which the intake point is located is 9: 2) the total amount attempted removed by surface water users (municipal intake points or surface water using basic industries) from the parcel on which the intake point is located is greater than the amount of water on the parcel; 3) the intake

```
************************************************************************************************************
                        TWOCITY
                   WATER DEPARTMENT REPORTS                                                  JURISDICTION 1
************************************************************************************************************

INTAKE TREATMENT PLANTS
-----------------------
                                     INTAKE   WATER      WATER                 TOTAL
                             INFLOW   WATER   NEEDED   OBTAINED  CAPACITY   TREATMENT    TREATMENT      INCOME
    PLANT  LOCATION  LEVEL   POINT   QUALITY   (MGD)     (MGD)     (MGD)       COST      COST/MGD    FROM USERS
    -----  --------  -----  ------   -------  ------   --------  --------  ---------   ---------    ----------

      1      9424      4     9624       1      14.45     14.45       26     $   25889   $  1791     $   2010014


OUTFLOW TREATMENT PLANTS
------------------------
                     TYPE              AMOUNT OF    PLANT         TOTAL
                      AND    OUTFLOW   EFFLUENT   CAPACITY     TREATMENT    TREATMENT
    PLANT  LOCATION  LEVEL    POINT      (MGD)      (MGD)         COST       COST/MGD
    -----  --------  -----  -------  ---------   --------     ---------    ---------

      1      9428     TT4     9616     14.45         26       $ 1321263    $ 91436


MUNICIPAL SAMPLING STATION REPORTS
----------------------------------
                                                         BACTERIALS  TEMPERATURE   OIL AND   HIGH      AMOUNT OF
                         BOD       CHLORIDES   NUTRIENTS   (PARTS     DEVIATION   FLOATING  LEVEL       WATER
  DIST   LOCATION     (LBS/MG)     (LBS/MG)    (LBS/MG)    PER MG)    (DEGREES)    SOLIDS   WASTES      (MGD)
  ----   --------     --------     --------    --------  ----------  -----------  --------  ------   ---------

    1      9616        11.65         4.49        26.98       0.0          0.0         NO       NO        14.45

WATER PRICES
------------
                     ACTIVITY        PRICE/MG
                     --------        --------                                   LA       $        200
                                                                                LB       $        450
                       OUT       $       700          SG        $        450    LC       $        450
                       NS        $       450          MF        $        450    MA       $        450
                       CI        $       450          NL        $        450    MB       $        450
                       BG        $       350          EL        $        450    MC       $        450
                       BS        $       450          TE        $        450    HA       $        300
                       PG        $       450                                    HB       $        450
                       PS        $       450                                    HC       $        450
```

FILMED FROM BEST AVAILABLE COPY

treatment plant has the capacity to process a volume less than the total amount needed by the district's water users. In the first case, no water users supplied by the municipal system receive municipal water; all purchase from the Outside. In the second and third cases each water user receives a share of municipally-supplied water proportional to its needs. If both the second and third cases obtain, the lesser amount is removed from the surface water and treated.

The seventh item, total treatment cost, is the plant's operating cost for the year, based on the total water users' annual requirements (in MG), the proportion of their daily needs (MGD) which the district obtained, and the quality of the intake water. The proportion is multiplied by the total annual requirement and then multiplied by the cost per MG to treat water at the intake quality. For example, suppose that a district contained only a BG1 and a TE1, had a level 1 intake plant, quality 4 intake water, and no shortage of water at the intake point. Suppose that the Master Tables showed that: a BG1 requires .17 MGD and 41 MG annually; a TE1 requires 8 MGD and 2080 MG annually; a level 1 intake plant can treat 3 MGD; and the cost per MG to treat quality 4 water is \$100. Then the total amount needed (MGD) would be 8.17. The amount obtained would be 3.00, and the capacity would be 3.00. The total treatment cost would be:

$$3.00/8.17 \times (41 + 2080) \times \$100 = \$77882$$

The treatment cost per MGD is the total treatment cost divided by the MGD obtained.

The last item on the table, income from users, is the total income from the district's sale of water. It is shown on the intake treatment plant table because water users pay the department only for those portions of their water needs which are provided locally. They pay the local price per MG for the number of MG's obtained from the district.

Whereas a water user may obtain some of its water from Outside, all of its effluent is dumped into the municipal sewer system (for municipal water users only). Thus a district receives revenue only for water provided but receives the total amount of effluent generated in the district. On the outflow treatment plant table, each outflow plant has a row. The first two columns contain the code number of the utility district in which the plant is located and which it serves, and the coordinates of the outflow plant.

The third column is the treatment type and level. Level denotes the maximum amount of effluent which the plant can treat. Type denotes the amount of each pollutant removed from the effluent which the plant treats. The four types of plants, in increasing order of pollution removal, are: chlorination (CL), primary treatment (PT), secondary treatment (ST), and tertiary treatment (TT).

The sewage generated by a district may be dumped into surface water anywhere in the simulated region, although all of the outflow for a single district must be on a single surface water parcel. The coordinates of the parcel on which the district's outflow point is located are given in the fourth column. All of the district's effluent, treated or not, is dumped on that parcel.

The fifth column contains the amount of effluent (in MGD) generated by all of the water users in the district. That amount is equal to the amount of water needed shown on the intake treatment plant table. The plant capacity (in MGD) is in the next column and is the maximum amount which can be treated. If the amount of effluent is greater than the plant capacity, the difference between the amount of effluent and the amount treated is dumped untreated at the outflow point. The amount treated has an amount of pollution removed according to the treatment type.

The total treatment cost, the treatment plant's operating cost for the year, is based on the total water users' annual requirements (in MG), the proportion of their effluent which the plant treated, and the treatment cost per MG for the treatment type and level. The proportion is multiplied by the total annual requirement and then by the treatment cost per MG for the treatment type. For example, suppose that the same district in the example above had ST2 effluent treatment, and that the Master Tables showed that a level 2 has a capacity of 8 MGD and that the treatment cost per MG at ST2 is $190. The total treatment cost would be:

$$8.00/8.17 \times (41 + 2080) \times \$190 = \$394,605$$

The last column, treatment cost per MGD, is the total treatment cost divided by the amount treated (in MGD).

The department can set up sampling stations to monitor the concentration of each pollutant in the municipal effluent which it dumps into the surface water. Municipal sampling stations must be located on parcels where municipal systems have outflow points. The municipal sampling station report is a table with one row per sampling station. The first two columns contain the code number of the utility district which the outflow point serves and the coordinates of the outflow point. The next seven columns show the concentration of each pollutant in the effluent being dumped (after any treatment). Oil and floating solids and high level wastes are either present or not; they are not measured in concentrations. Suppose that in the example given above, the Master Table showed the effluent content of a BG1 and a TE 1 to be:

	BOD (LBS/MG)	Chlorides (LBS/MG)	Nutrients (LBS/MG)	Coliform (parts/MG)	Temperature Deviation	Oil & Floating Solids	High Level Wastes
BG1	200	0	0	10	0	No	No
TE1	500	180	100	30	0	No	No

Then the volume of pollution before treatment would be:
BOD: 200 x .13 + 500 x 8 = 4026 Lbs.
Chlorides: 0 x .13 + 180 x 8 = 1440 Lbs.
Nutrients: 0 x .13 + 100 x 8 = 800 Lbs.
Coliform: 10 x .13 + 30 x 8 = 241.3

The amount of pollution to be treated would be 8.00/8.17 of the amount in the effluent. Thus, the amount treated and untreated would be:

	Treated	Untreated
BOD	3945	81
Chlorides	1411	29
Nutrients	784	16
Coliform	236	5

Suppose that the Master Table showed that ST removed:

BOD	Chlorides	Nutrients	Coliform	Temperature	Oil & Floating Solids	High Level Wastes
80%	60%	50%	99%	0%	100%	0%

Then the amount of pollution remaining in the treated effluent would be:

BOD: (100 - 80) x 3945 = 789
Chlorides: (100 - 60) x 1411 = 564
Nutrients: (100 - 50) x 784 = 392
Coliform: (100 - 99) x 236 = 2

The total amount of pollution dumped would be:

BOD;	789 + 81 = 870
Chlorides:	564 + 29 = 593
Nutrients:	392 + 16 = 408
Coliform:	2 + 5 = 7

The sampling station report would show those concentrations to be:

BOD:	106.49 LBS/MG	(870/8.17)
Chlorides:	72.58 LBS/MG	(593/8.17)
Nutrients:	49.94 LBS/MG	(408/8.17)
Coliform:	.86 PARTS/MG	(7/8.17)

The last column in the table is the total volume of effluent dumped at the outflow point. Actually, the volume of effluent dumped is unimportant, since the amount of surface water on a parcel is constant. What does matter is the total amount of pollution dumped, not its concentration. Once in the surface water, the concentration of each pollutant depends on the volume of the surface water and the amount of each pollutant already in the surface water, not on the amount of effluent.

Water prices are the last section of the Water Department Report. The two-letter code of each activity and the price per MG are listed. The first activity, OUT, is the Outside price per MG which water users pay for any water which they cannot obtain locally. That price is the same for all jurisdictions and is not controlled by the department.

All of the other prices in the list are set by the department. Note that the department does not set prices for basic industries which use surface water, since those industries obtain and treat their own water. The department sets one price for each type of economic activity except residences. Residence prices are set by residence type and by class. The first letter of the two-letter code is the class and the second is the residence type. 'LB' would be low-income living in residence type RB. Water consumption by a Pl varies by class and residence type. In general, high-income consume more water than low-income, and RA residents consume more water than RC residents. See the Master Tables for the exact amounts of water consumption.

Sampling Station Report: Point Source Quality

The department can sample the effluent discharged by any economic activities in the jurisdiction at a fixed cost per sampling station. The concentration of a basic industry's pollution is shown after any treatment provided by the industry.

The report is a table consisting of one row per sampling station. The first column shows the coordinates of the activity whose effluent is being sampled. Next are the economic owner and the type and operating level of the activity. The fourth column shows the effluent treatment type and level provided by the activity, but is relevant for basic industries only. A level one treatment plant has the capacity to process all of the effluent normally generated by one level of industry.

The volume of effluent (in MGD) is next. Basic industries which use surface water can recycle some of their water and cut the amount of effluent generated by up to half of the normal amount. Although the amount of effluent can be cut, the amount of pollution generated remains the same. Thus, the pollution concentration is higher in effluent when water is recycled, but no more pollution is present than there would be if there were no recycling.

The remainder of the table shows the concentration of each pollutant in the activity's effluent.

Sampling Station Report: Ambient Quality

An ambient sampling station measures the concentration of each pollutant in the surface water as it leaves a parcel and moves to the next parcel. Ambient sampling stations can be set up on any surface water parcels in the jurisdiction at a fixed cost per parcel. The type of information provided on the ambient sampling station report is basically the same as on other sampling station reports, except that the amount of water is the amount in the surface water, and the water is rated in a quality category (1-9).

Utility Department Report

This report contains detail on each utility plant in the jurisdiction and detail of importance to the department as a whole (water and utilities) on undeveloped land and outstanding bonds. The detail on utility plants consists of a table on which each row is a utility plant. The first two columns contain the utility district code number and the coordinates of the parcel on which the utility plant is

Figure 8.3

```
******************************************************************************************************************
                        TWOCITY
                   SAMPLING STATION REPORT: POINT SOURCE QUALITY                          JURISDICTION 1       ROUND  2
******************************************************************************************************************

                   BUSINESS  TREATMENT                                                 BACTERIALS   TEMPERATURE  OIL AND   HIGH
                   TYPE AND  TYPE AND   VOLUME      BOD      CHLORIDES   NUTRIENTS      (PARTS      DEVIATION  FLOATING  LEVEL
LOCATION   OWNER    LEVEL     LEVEL     (MGD)    (LBS/MG)    (LBS/MG)    (LBS/MG)      PER MG)     (DEGREES)    SOLIDS   WASTES
--------   -----   --------  ---------  ------   --------    --------    --------    ----------   -----------  --------  ------


  9422       B       RA 1         0      0.10    1070.00       37.00       77.00         5.00         0.0        YES      NO
  9424       C       RA 1         0      0.10    1070.00       37.00       77.00         5.00         0.0        YES      NO
  8826       B       RA 3         0      0.35    1100.00       40.00       80.00         5.00         0.0        YES      NO
  9026       F       RA 3         0      0.35    1100.00       40.00       80.00         5.00         0.0        YES      NO
  9226       E       RA 3         0      0.35    1100.00       40.00       80.00         5.00         0.0        YES      NO
  9426       E       RA 2         0      0.21    1100.00       40.00       80.00         5.00         0.0        YES      NO
  8628       C       RA 3         0      0.24    1250.00       50.00      100.00         5.00         0.0        YES      NO
  8828       B       RA 4         0      0.49    1100.00       40.00       80.00         5.00         0.0        YES      NO
  9228       B       PS 1         0      0.19     100.00        0.0         0.0         15.00         0.0        NO       NO
  9428       A       MF 0         0      0.0        0.0         0.0         0.0          0.0          0.0        NO       NO
  8430       E       RA 4         0      0.39    1223.08       48.21       96.41         5.00         0.0        YES      NO
  8630       E       RA 6         0      0.56    1250.00       50.00      100.00         5.00         0.0        YES      NO
  8830       B       RC 1         0      1.29    1190.70       46.05       92.09         5.00         0.0        YES      NO
  9030       D       RC 2         0      2.61    1179.31       45.29       90.57         5.00         0.0        YES      NO
  9230       E       PG 1         0      0.23     250.00        0.0         0.0         20.00         0.0        NO       NO
  8432       F       RA 6         0      0.48    1250.00       50.00      100.00         5.00         0.0        YES      NO
  8532       D       RA 6         0      0.56    1250.00       50.00      100.00         5.00         0.0        YES      NO
  8832       F       RA 2         0      0.15    1180.00       45.33       90.67         5.00         0.0        YES      NO
  9032       F       RB 3         0      1.38    1206.52       47.10       94.20         5.00         0.0        YES      NO
  9232       F       RC 1         0      0.96    1212.50       47.50       95.00         5.00         0.0        YES      NO
  8634       F       RA 4         0      0.39    1223.08       48.21       96.41         5.00         0.0        YES      NO
  8834       B       RA 3         0      0.24    1250.00       50.00      100.00         5.00         0.0        YES      NO
  9034       E       RB 1         0      0.50    1205.00       47.00       94.00         5.00         0.0        YES      NO
  9234       B       RB 3         0      1.52    1210.53       47.37       94.74         5.00         0.0        YES      NO
  8836       F       RA 5         0      0.48    1250.00       50.00      100.00         5.00         0.0        YES      NO
  9036       C       RA 2         0      0.15    1250.00       50.00      100.00         5.00         0.0        YES      NO
  9038       F       RA 1         0      0.08    1250.00       50.00      100.00         5.00         0.0        YES      NO
```

Figure 8.4

```
                    SAMPLING STATION REPORT: AMBIENT QUALITY                                   JURISDICTION 2        ROUND  1
****************************************************************************************************************************

                                                          BACTERIALS   TEMPERATURE    OIL AND     HIGH       AMOUNT OF     WATER
LOCATION      BOD        CHLORIDES     NUTRIENTS          (PARTS       DEVIATION     FLOATING    LEVEL        WATER       QUALITY
            (LBS/MG)     (LBS/MG)      (LBS/MG)           PER MG)      (DEGREES)      SOLIDS     WASTES       (MGD)       RATING
--------    --------     ---------     ---------        ----------    -----------    --------    ------     ---------     -------

  9620        0.0          0.0           10.20             0.0           0.0           NO          NO         260.00         1
  9622        0.0          0.0            9.22             0.0           0.0           NO          NO         254.00         1
  9624        0.0          0.0            7.86             0.0           0.0           NO          NO         280.00         1
  9626      106.90        53.45         861.54             0.05          0.43          NO         YES         290.00         1
  9612        0.0          0.0            0.0              0.0           0.0           NO          NO         100.00         1
  9614        0.0          0.0            6.67             0.0           0.0           NO          NO         150.00         1
  9616        0.0          0.0            9.70             0.0           0.0           NO          NO         200.00         1
  9618        0.0          0.0           11.29             0.0           0.0           NO          NO         250.00         1
  9628      131.41        50.92         799.11             0.43          0.0          YES         YES         300.00         8
  9630      424.74       135.72        1150.11             1.08         10.66         YES         YES         500.00         8
  9632      401.90       127.26        1125.40             0.98          7.45         YES         YES         510.00         9
  9432      967.50       153.13        1982.20            29.53          5.15         YES         YES         520.00         9
 11830        0.0          0.0            0.0              0.0           0.0           NO          NO          70.00         1
 11630        0.0          0.0            0.0              0.0           0.0           NO          NO          80.00         1
 11430        0.0          0.0            0.0              0.0           0.0           NO          NO          90.00         1
 11230        0.0          0.0            0.0              0.0           0.0           NO          NO         100.00         1
 11030        0.0          0.0            0.0              0.0           0.0           NO          NO         100.00         1
 10830        0.0          0.0            0.0              0.0           0.0           NO          NO         100.00         1
 10630        0.0          0.0            0.0              0.0           0.0           NO          NO         100.00         1
 10430        0.0          0.0           11.25             0.0           0.0           NO          NO         120.00         1
 10230        0.0          0.0            8.45             0.0           0.0           NO          NO         150.00         1
 10030        0.0          0.0            7.01             0.0           0.0           NO          NO         170.00         1
  9830        0.0          0.0            5.60             0.0           0.0           NO          NO         192.00         1
```

FILMED FROM BEST AVAILABLE COPY

Figure 8.5

```
                                TWOCITY
                                       UTILITY DEPARTMENT REPORT                           .  JURISDICTION 1
*************************************************************************************************************
                                          UNITS         UNITS      OPERATING     OPERATING
PLANT    LOCATION       LEVEL           INSTALLED      SERVED        COSTS       COST/UNIT         INCOME

-----------------------------------------------------------------------------------------------

  1        94-24          2               5000          1166      15773330.        13527.        11310200.

                                                     TOTALS       15773330.                      11310200.
CHARGE TO CUSTOMERS --        9700 PER UNIT


UNDEVELOPED LAND
----------------
          LOCATION  AMOUNT    LOCATION  AMOUNT    LOCATION  AMOUNT    LOCATION  AMOUNT    LOCATION  AMOUNT
          --------  ------    --------  ------    --------  ------    --------  ------    --------  ------
            94-24       7       82-30       4       94-28       9


                              OUTSTANDING BONDS
                              -----------------


    TYPE             ORIGINAL       REMAINING     INTEREST          ANNUAL
                     PRINCIPAL        TERM          RATE            PAYMENT
    ----             ---------      ---------     --------          -------

   CAPITAL            7182128.         8             4.1            464614.
   CURRENT             200000.         1             3.2            104825.
   CURRENT             150000.         2             3.2             78618.
   CURRENT            7430000.         2             3.7           3922430.
```

located. Next is the level of utility plant. Each level has a fixed capacity in terms of the number of utility units which it can provide.

The next two columns show the number of utility units installed on parcels served by the plant. The number of units installed on a parcel is the maximum number which an activity located there can draw upon. The program rejects any construction which would require more utility units than are installed on the parcel. The number of units installed and attached to a plant are always greater than or equal to the number of units served by the plant. The units served are those actually being consumed. Units installed indicates actual and potential consumption. However, a level of a plant has a maximum capacity in terms of units served. That maximum cannot be exceeded.

There is an optimum number of units which a level of utility plant can serve. Below and above that number the operating cost per unit served (equal to a unit of income) is greater than that optimal minimum cost per unit served. Column six, total operating cost for the year, is less informative than column seven, the operating cost per unit served. The last column shows the total income which the district receives for providing utility service. An economic activity pays for only the number of utility units which it drains, regardless of the number installed on the parcel on which the activity is located.

The undeveloped land table shows the location and percent of parcel owned wherever the department owns undeveloped land. Utility plants, intake treatment plants, and outflow treatment plants require land. When a building is constructed, land is subtracted from the department's undeveloped land account.

Each outstanding bond is listed on the bond table, one row per bond. The first item is the type of bond, capital or current. A capital bond has a term of 25 years; a current bond has a term of 2 years. The original principal, remaining term, interest rate, and annual payment are given. The remaining term is the number of rounds after the current round in which the department must make the annual payment. The annual payment is calculated by the computer to pay off the bond in equal installments each year, and the payment is made automatically by the computer from the department's current account.

COMPUTER OUTPUT EXPLANATION FOR THE SCHOOL DEPARTMENT

The School Department for each jurisdiction receives three sections of computer output: the SCHOOL DEPARTMENT REPORT, the CONSTRUCTION TABLE, and SCHOOL DEPARTMENT FINANCES.

School Department Output

This report information is divided into five sections:

1. School Units - supply, demand and use index for each school district.
2. Undeveloped Land - location and amount of undeveloped land owned by the department.
3. Contracts - contractural agreements to purchase business goods and services from specific suppliers.
4. Adult Education - supply of and demand fro adult education programs.
5. Boycotts - information on social classes boycotting School Department jobs.

1. Characteristics of School Facilities

The first column gives the numerical identification of the School facility. Each facility in the local system is given a unique identification number that is used on the computer maps.

The second column gives the parcel location of the School facility. The third column provides the development level of the School facility. These facilities may be built or upgraded to one of three levels.

The fourth column gives the maintenance level for the school facilities. The department may change the maintenance level for any school facility. The maintenance level is the lowest level to which the value ratio will be allowed to decline before maintenance expenditures are incurred.

The fifth column is the value ratio for each school facility. The value ratio is a measure of the present value and effectiveness of the plant and equipment in relation to "brand new" plant and equipment. A value ratio of 80 means that the effective capacity of an educational facility is reduced to 80 percent of what it would be if the value ratio were 100.

Figure 8.11

```
**************************************************************************************************************
 BLUECITY
                    S C H O O L   D E P A R T M E N T                                 JURISDICTION 1    ROUND  7
**************************************************************************************************************

 S C H O O L   U N I T S
 ---------------------

                                                          S T U D E N T S
                           MAINTENANCE       VALUE     -----------------------     TEACHER, REQUESTED   STUDENT/TEACHER
SCHOOL  LOCATION LEVEL        LEVEL          RATIO      HIGH     MIDDLE     LOW      HIGH    MIDDLE         RATIO            USE INDEX
-------------------------------------------------------------------------------------------------------------------------------------


   1     9030      1            5              89         0      12790     5700       3        3             22                 103
   2    10026      1           84              84         0          0    14600       2        2             26                 137
   3     9032      1           94              94      2600       7420        0       2        2             18                  84
   4     9834      1           84              84         0      11200     1100       2        2             22                 116

           U N D E V E L O P E D   L A N D
           ---------------------------


                       LOCATION    AMOUNT
                       --------    ------
                         11234       16

     C O N T R A C T S
     ---------------
                                   PERCENTAGE   OF   COST PER       CAPACITY      TOTAL
     TYPE   OWNER   LOCATION     TOTAL PURCHASES       UNIT        UNITS USED     COST
     ------------------------------------------------------------------------------------------------------------------


      86      C      98- 30           100            110000           44         4840000
      85      B      98- 32           100             97500           16         1560000

        A D U L T   E D U C A T I O N                                            6400000
        ---------------------------

        EMPLOYMENT REQUESTED         EMPLOYMENT OBTAINED
        ------------------------------------------------
         HIGH        MIDDLE          HIGH      MIDDLE      ACTUAL CAPACITY    USED CAPACITY      UNMET DEMAND
     -----------------------------------------------------------------------------------------------------


         584         584             584       584            14600                14596         1985



     SCHOOL AGE POPULATION IS                                 106580
     NUMBER OF STUDENTS ATTENDING LOCAL SCHOOLS                55360
     NUMBER OF STUDENTS ATTENDING PRIVATE  SCHOOLS             51220
     SALARY OFFERED HIGH INCOME TEACHERS                       10100
     SALARY OFFERED MIDDLE INCOME TEACHERS                      5000
```

The sixth, seventh and eighth columns show the number of students from each of the three classes that attend public schools in each of the districts.

Columns nine and ten show the employment mix requests in terms of population units. The final column shows the School Use Index. It is the ratio of loading (demand) to effective capacity (supply) multiplied times 100.

If the School Department did not hire all the population units it requested, the following message is printed:

"7 MIDDLE INCOME TEACHER REQUESTS NOT FILLED"

This would indicate that 7 PM's were not hired.

2. Undeveloped Land

This table shows the parcel location for undeveloped land owned by the School Department. It also shows the percent of the parcel owned by the department. The percent of a parcel required for a level one school facility is shown in the School Master Table.

3. Contracts

The School Department purchases goods and services each round as part of the costs of operating and maintaining their school facilities. These purchases are made from BG and BS establishments in the local system if contracts to do so are submitted to the computer by the department. If no contracts to purchase locally supplied goods and services are made, then all needed purchases are made from the outside system.

The contract table shows the type of good or service in column one. In the second column, the owner of the establishment supplying the good or service is indicated. The third column shows the parcel location of the supplier if it is a supplier within the local system.

The fourth column shows the percent of total purchases made from BS and BS suppliers. The fifth column shows the cost per BG and BS unit being charged by the supplier. (The outside prices are fixed.)

The sixth column shows the number of BG and BS units purchased and the last column shows the total cost. This cost is derived by multiplying the cost per unit times the number of units purchased.

5. Adult Education

The School Department may operate a public adult education program if it wishes and can afford to pay the costs. The demand for public adult education is generated by the time allocations for free adult education by population units in the Social Sector.

It is assumed that adult education is carried out in the same school facilities used by the children in the public schools; therefore, the only cost to supplying adult education services is the hiring of part-time teachers. Teachers may be hired in any desired mix from the PH and PM classes.

The first two columns show the number of part-time work units requested by the School Department from the PH and PM classes, respectively. Since the School Department competes in the labor market with all other employers of part-time workers, there is a chance that occasionally not all the teachers sought will actually be hired. Therefore, columns three and four show the part-time work units actually obtained.

The capacity of the adult education program is obtained by multiplying the high income part-time units actually hired times 15 and added that to the number of middle income part-time units multiplied by 10. Thus PH teachers provide 50 percent more capacity per work unit hired than PM teachers.

The used capacity is the number of leisure time units allocated to public adult education that were able to be served by the actual capacity of the adult education program. The unmet demand (if any) is the excess of the desired amount of time spent in public adult education by the population units of the local jurisdiction over the amount that was actually able to be spent given the capacity of the jurisdiction's adult education program.

At the bottom of the Adult Education Table, the local school age population in the jurisdiction is shown along with the number of these students who attended the public schools and the number who attended private schools. The population units whose children attended private schools had to pay the specified tuition per student as shown in the School Master Table.

The salary offered PH and PM teachers is also listed at the end of the Adult Education Table. The same salary is offered to full time teachers for day classes and part-time teachers for adult education classes.

5. Boycotts

The Boycott Table shows three bits of information on the boycotting population units (team controlling, income class, and function which for School boycotts will always be work). Three bits of information are formatted for the boycotted employer. When the School Department is the employer being boycotted, "SC" and the jurisdiction number appear under the third column heading entitled "owner".

NEW CONSTRUCTION

The Construction Table shows projects that were completed at the beginning of the round and therefore were in operation for the entire round. "Outside" indicates that an outside construction firm performed the construction. The site location is the parcel on which the school facility was constructed. The status will always appear as "Completed".

Old level is the previous development level for the school facility. A zero indicates that no school facility previously existed on that parcel. The new level is the present development level for the school facility after the construction. The price of construction is indicated along with the department specified maintenance level (this applies to the entire structure) and the specified employment mix (this applies to the entire structure) and the specified employment mix (this applies to the new total level not only to the newly constructed increment).

SCHOOL DEPARTMENT FINANCES

Outstanding Bonds - This table shows the type (capital or current) of bond, the original principal, the number of rounds remaining to pay off the bond (all bonds start as 25 or 2 year bonds), the rate of interest being charged on the principal (determined by the state of the national bond market in the year the bond was floated), and the annual payment that must be made on the debt. Bond payments on a bond floated in round T being in round T+1. Thus a current bond incurred in Round 2 will start being paid off in Round 3.

Figure 8.12

```
*****************************************************************************************************
  BLUECITY
                         S C H O O L   F I N A N C E S                            JURISDICTION 1
*****************************************************************************************************


             CAPITAL                                             CURRENT

REVENUES                                          REVENUES

PREVIOUS CASH BALANCE          792800             PREVIOUS CASH BALANCE          30711900
APPROPRIATIONS               13500000             APPROPRIATIONS                 19000000
FEDERAL-STATE AID USED              0             FEDERAL-STATE AID USED         12456000
NEW BONDS                           0             NEW BONDS                             0
MISCELLANEOUS                       0            MISCELLANEOUS                   16000000
                           ----------                                          ----------
       TOTAL                 14292800                                          78167900


EXPENDITURES                                      EXPENDITURES

SCHOOL CONSTRUCTION                 0             GOODS AND SERVICES              6400000
LAND PURCHASES                      0             FULL-TIME SALARIES             18108000
MISCELLANEOUS                       0             MISCELLANEOUS                         0
                                                  BOND PAYMENTS                         0
                                                  ADULT EDUCATION                14687600
                           ----------                                          ----------
       TOTAL                        0                                            39195600


CURRENT BALANCE              14292800             CURRENT BALANCE                38972300



THERE ARE NO OUTSTANDING BONDS


F E D E R A L / S T A T E   A I D   A V A I L A B L E   F O R   S C H O O L   C O N S T R U C T I O N
--------------------------------------------------------------------------------------------------------

         NONE
```

COMPUTER OUTPUT EXPLANATION FOR THE MUNICIPAL SERVICES DEPARTMENT

Municipal Services Department Output

This report information is divided into five sections:

1. MS Characteristics - supply, demand and use index for each MS plant and totals for the jurisdiction
2. Contracts - contractual agreements to purchase business goods and services from specific suppliers
3. Undeveloped Land - location and amount of undeveloped land owned by the department
4. Outstanding Bonds - information on bonds still requiring annual payments
5. New Construction - information on the location, costs, and operating characteristics of new MS facilities.
6. Boycotts - information on social classes boycotting MS jobs.

1. MS Characteristics

The first column gives the numerical identification of the MS facility. Each facility in the represented area is given a unique identification number that is used on the computer maps.

The second column gives the parcel location of MS facility. The third column provides the development level of the MS facility. These facilities may be built or upgraded to one of three levels.

The fourth column gives the maintenance level for the MS facilities. The department may change the maintenance level for any MS facility. The maintenance level is the lowest level to which the value ratio will be allowed to decline before maintenance expenditures are incurred.

The fifth column is the value ratio for each MS facility. The value ratio is a measure of the value and effectiveness of the plant and equipment in relation to "brand new" plant and equipment. A value ratio of 80 means that the effective capacity of a MS facility is reduced to 80 percent of what it would be if the value ratio were 100.

Figure 8.7

```
                              TWOCITY
                              MUNICIPAL SERVICES DEPARTMENT REPORT                              JURISDICTION 2
**********************************************************************************************************
                          MAINTENANCE    VALUE    EFFECTIVE CAPACITY                 EMPLOYMENT    M.S. USE
MS  LOCATION    LEVEL        LEVEL       RATIO       OF SERVICE        LOADING     LOW   MIDDLE       INDEX
----------------------------------------------------------------------------------------------------------

 3    98-26       1           85          85            935              900        3      3            96
 5   110-34       1           95          96            825                0        3      2             0

TOTALS                                                    0              900        6      5            96
SALARY OFFERED LOW  2900;  MIDDLE   4900.

WELFARE PAYMENT PER UNEMPLOYED WORKER IS 1600.


 C O N T R A C T S


----------------
                              PERCENTAGE  OF   COST PER      CAPACITY       TOTAL
 TYPE   OWNER   LOCATION     TOTAL PURCHASES       UNIT      UNITS USED      COST

----------------------------------------------------------------------------------------------------------

  BG   OUTSIDE                     100          130000          18         2340000
  BS     B       98- 32             10          100000           0               0
  BS   OUTSIDE                      90          130000           8         1040000

                                                                           3380000


UNDEVELOPED LAND :
----------------
        LOCATION  AMOUNT    LOCATION  AMOUNT    LOCATION  AMOUNT    LOCATION  AMOUNT    LOCATION  AMOUNT
        --------  ------    --------  ------    --------  ------    --------  ------    --------  ------
          94-30     12        114-18     8        106-28    12         88-20     6


                            OUTSTANDING BONDS
                            -----------------


   TYPE           ORIGINAL      REMAINING     INTEREST        ANNUAL
                  PRINCIPAL       TERM          RATE          PAYMENT
   ----           ---------     ---------     --------        -------

  CAPITAL           855348.        2            4.8             59478.
  CURRENT         15870000.        1            3.0           8293933.
  CAPITAL          1500000.       25            3.1             87104.
  CURRENT         64040000.        2            3.5          33710687.
```

The sixth column is the effective capacity of service or the MS supply provided by each MS facility. This number is derived by finding the capacity that would be supplied as determined by the MS level and employment mix and multiplying this times the value ratio expressed as a percent.

The seventh column is the MS loading or MS demand generated by the population units and business activities located within the MS district boundaries. The MS units demanded by each type of activity is shown in the MS Master Table.

Columns eight and nine show the employment mix requestes in terms of population units. The final column shows the MS Use Index. It is the ratio of loading (demand) to effective capacity (supply) multiplied times 100.

The salaries offered per worker to PL and PM employees is listed below the table along with the designated welfare payment per unemployed worker.

If the MS Department did not hire all the population units it requested, the following message is printed :

"EMPLOYMENT SHORTAGE LOW 5; MIDDLE 0"
This would indicate that 5 PL's were not hired.

2. Contracts

The MS Department purchases goods and services each round as part of the costs of operating and maintaining their MS facilities. These purchases are made from BG and BS establishments in the local system if contracts to do so are submitted to the computer. If no contracts to purchase locally supplied goods and services are made, then all needed purchases are made from the outside system.

The contract table shows the type of good or service in column one. In the second column, the owner of the establishment supplying the good or service is indicated. The third column shows the parcel location of the supplier if it is a supplier within the local system.

The fourth column shows the percent of total purchases made from BG and BS suppliers. The fifth column shows the cost per BG and BS unit being charged by the supplier. (The outside prices are fixed.)

The sixth column shows the number of BG and BS units purchased and the last column shows the total cost. This cost is derived by multiplying the cost per unit times the number of units purchased.

3. Undeveloped Land

This table shows the parcel location for undeveloped land owned by the MS Department. It also shows the percent of the parcel owned by the department. The percent of a parcel required for a level one MS facility is shown in the MS Master Table.

4. Outstanding Bonds

This table shows the type (capital or current) of bond, the original principal, the number of rounds remaining to pay off the bond (all bonds start as 25 or 2 year bonds), the rate of interest being charged on the principal (determined by the state of the national bond market in the year the bond was floated), and the annual payment that must be made on the debt. Bond payments on a bond floated in round T begin in round T+1. Thus a current bond incurred in Round 2 will start being paid off in Round 3.

5. New Construction

The Construction Table shows projects that were completed at the beginning of the round and therefore were in operation for the entire round. "Outside" indicates that an outside construction firm performed the construction. The site location is the parcel on which the MS facility was constructed. The status will always appear as "Completed".

Old level is the previous development level for the MS facility. A zero indicates that no MS facility previously existed on that parcel. The new level is the present development level for the MS facility after the construction. The price of construction is indicated along with the department specified maintenance level (this applies to the entire structure) and the specified employment mix (this applies to the new total level not only to the newly constructed increment).

6. Boycotts

The Boycott Table shows three bits of information on the boycotting population units (team controlling, income class, and function which for MS boycotts will always be work). Three bits of information are formatted for the boycotted employer. When the MS Department is the employer being boycotted, "MS" and the jurisdiction number appear under the third column heading entitled "owner".

Municipal Services Department Finances

This report summarizes the department's financial transactions for the previous year. See the Introduction to the Government Sector for detail on the standard governmental budgetary procedure.

Figure 8.8

MS.2.3 MUNICIPAL SERVICES DEPARTMENT FINANCES

```
*******************************************************************************************
    TWOCITY
    MUNICIPAL SERVICES DEPARTMENT FINANCES              JURISDICTION 2         ROUND  2
*******************************************************************************************



                        FINANCIAL ACCOUNTING

        CAPITAL                                           CURRENT
   PREVIOUS CASH BALANCE           0.          PREVIOUS CASH BALANCE          8331.

   REVENUES                                    REVENUES
       APPROPRIATIONS              0.            APPROPRIATIONS           12000000.
       BONDING               1500000.            BONDING                  64040000.
       MISC. INCOME        120000000.            MISC. INCOME                    0.
                                                 FED/STATE AID              556500.


                             -------                                      -------
   TOTAL                   121500000.          TOTAL                      76596500.

   EXPENDITURES                                EXPENDITURES
       CONSTRUCTION         36000000.            WELFARE PAYMENTS         57216000.
       LAND PURCHASE            5000.            GOODS + SERVICES          3380000.
       MISCELLANEOUS               0.            MISCELLANEOUS                   0.
                                                 SALARIES                  7400000.
                                                 BOND PAYMENTS             8606752,


                             -------                                      -------
   TOTAL                    36005000.          TOTAL                      76602752.

   NEW CASH BALANCE         85495000.          NEW CASH BALANCE               2079.
```

Planning and Zoning Department Report

This one-page output summarizes the amount of parkland and public institutional land provided by the department and the financial status of the department.

The department has the power to purchase land for parks and to develop parkland into public institutional (museums, zoos, etc.) land uses. Park facilities affect where people select housing.

The department also has the power to zone land to restrict what types of economic developments can be constructed on specific parcels. The department can greatly affect the pattern and rate of growth in the jurisdiction.

Further details on Planning and Zoning are contained in the description of the maps which most directly relate to this department.

Figure 8.10

```
**************************************************************************
  TWOCITY
   PLANNING & ZONING DEPARTMENT REPORT     JURISDICTION 1     ROUND  2
**************************************************************************


          THE POPULATION IS  123000

          TOTAL PARKLAND IS 3.96 SQUARE MILES

          TOTAL INSTITUTIONAL LAND IS 0.0   SQUARE MILES

          POPULATION PER SQUARE MILE OF INSTITUTIONAL LAND IS        0
                              (NATIONAL AVERAGE IS 100000)


          THERE ARE NO OUTSTANDING BONDS


                        FINANCIAL ACCOUNTING

            PREVIOUS CASH BALANCE          2000000.

            REVENUES
                APPROPRIATIONS             2000000.
                BONDING                          0.
                MISCELLANEOUS                    0.


                                           -------
            TOTAL                          2000000.


            EXPENDITURES
                PUBLIC INSTITUTIONS              0.
                BOND PAYMENTS                    0.
                LAND PURCHASE                    0.
                MISCELLANEOUS               380000.


                                           -------
            TOTAL                           380000.


            NEW CASH BALANCE               3620000.
```

Highway Department Output

The Highway Department controls the construction of roads and terminals and the maintenance of roads. Roads are located between parcels and consume land from both adjoining parcels; a terminal is located at corners of parcels (intersection) and consumes land from the four parcels which border the intersection. Roads are used by population units to travel to and from employment and shop locations and by basic industry and commercial establishments to transport products to terminals and to purchase the necessary goods and services for maintenance and normal operations. Population units travel to work during peak-hour travel only.

There are three types of highways: HY1, HY2, HY3. An HY3 is the largest road, and the cheapest to travel on. The type of road determines its design capacity in terms of the number of vehicles which it can handle without congestion when it is in the best condition. Highways depreciate as a function of use. The value ratio of a segment of highway is the percent of its design capacity which it can actually handle. The lower the value ratio of a road, the less its effective capacity.

Road congestion occurs when there are more vehicles using a road segment than can be handled by the road. Congestion is recorded only during peak-hour travel. When congestion occurs, it takes additional time for population units to travel along the congested road segment. The amount of additional time is directly proportional to the amount of congestion on the highway. For example, if the peak-hour congestion is 110%, the time to travel a road is 10% greater than otherwise. Time consumed in transportation to and from work affects the allocation of leisure time in the social sector.

Terminals are used by heavy industry, light industry, and business goods. Industries use terminals to ship output to national demanders and BG receives goods from national suppliers.

Highway Department Finances

The Highway Department receives income to its current and capital accounts from various sources. These include appropriations, Federal-State aid, bonds, and miscellaneous income. Appropriations are distributed to the current and/or capital accounts of the department by the Chairman. The

Figure 8.14

```
*****************************************************************************************************************************
                    TWOCITY
                              HIGHWAY DEPARTMENT FINANCES                                     JURISDICTION 1        ROUND  1
*****************************************************************************************************************************


F I N A N C I A L   R E P O R T
-----------------------------

                    CAPITAL                                                  CURRENT
                    -------                                                  -------


      PREVIOUS BALANCE          $        0.0                 PREVIOUS BALANCE          $        0.0


      REVENUES                                               REVENUES
           APPROPRIATIONS       $        0.0                      APPROPRIATIONS       $  500000.00
           FEDERAL/STATE AID             0.0
           NEW BONDING                   0.0                      NEW BONDING             270000.00
           MISCELLANEOUS                 0.0                      MISCELLANEOUS                 0.0
      TOTAL REVENUE             $        0.0                 TOTAL REVENUE             $  770000.00


      EXPENDITURES                                           EXPENDITURES
           ROAD CONSTRUCTION    $        0.0                      ROAD MAINTENANCE     $  406227.00
           TERMINAL CONSTRUCTION         0.0                      BOND PAYMENTS           354766.00
           LAND PURCHASE                 0.0
           MISCELLANEOUS                 0.0                      MISCELLANEOUS                 0.0
      TOTAL EXPENDITURES        $        0.0                 TOTAL EXPENDITURES        $  760988.00


      NEW BALANCE             $          0.0                 NEW BALANCE             $      9012.00


                         OUTSTANDING BONDS
                         -----------------


    TYPE          ORIGINAL     REMAINING    INTEREST        ANNUAL
                  PRINCIPAL      TERM         RATE          PAYMENT
    ----          ---------    ---------    --------        -------

   CAPITAL         3332474.     13             5.0          236447.
   CURRENT          270000.      2             3.0          141104.


M A I N T E N A N C E
---------------------


       ROAD         MAINTENANCE        TOTAL.      AVERAGE DEPRECIATION
       TYPE            LEVEL           MILES        BEFORE MAINTENANCE           COST
       ----         -----------        -----       --------------------      -------------


        1              90.0             10                  0.6              $      48000.
        2              90.0             12                  0.5              $     100445.
        3              90.0             11                  1.0              $     257778.
```

Figure 8.14 (Cont'd)

```
R O A D   C O N D I T I O N S   B E F O R E   M A I N T E N A N C E
--------------------------------------------------------------------

        VALUE RATIO   ROADS
                 .
        .........:..........................................................................
                 .
         95 - 90 .  9514  9518  9522  8823  9023  9223  9423  8827  8728  9128  9130  7031  7231  7431  7631
                 .     0     0     0     0     0     0     0     6     0     0     1     0     0     0     0
                 .
                 .  7831  8031  8231  8431  9136  8730
                 .     0     0     0     0     0     0
                 .
                 .
        .........:..........................................................................
                 .
         90 - 85 .  9526  9027  9227  9427  9231  8631  8831  8732  9031  8833  8934  9035
                 .    31    29    29    57    99    10    44    35    68    26    19    13
                 .
                 .
        .........:..........................................................................
                 .


        THERE ARE NO ROADS IN THIS JURISDICTION WITH VALUE RATIOS BELOW 85


T E R M I N A L S
-----------------


UNDEVELOPED LAND
----------------
        LOCATION  AMOUNT    LOCATION  AMOUNT    LOCATION  AMOUNT    LOCATION  AMOUNT    LOCATION  AMOUNT
        --------  ------    --------  ------    --------  ------    --------  ------    --------  ------
          86-22      4        88-22      4        90-22      4        92-22      4        94-22      4
          86-24      4        88-24      4        90-24      4        92-24      4        94-24      4


FEDERAL/ STATE AID AVAILABLE FOR HIGHWAY CONSTRUCTION
-----------------------------------------------------

                N O N E
```

department must request Federal-State aid for road construction from the computer and if it is granted, the aid can be used only for the approved project. The department does not receive the aid until the approved project is performed. Current bonds are automatically floated by the computer if the current expenditures of the department exceed its current revenue. Current bonds have a duration of two years and the interest rate is set by the computer. Capital bonds may be floated for the department by the Chairman subject to a referendum by the social sector. Capital bonds have a duration of 25 years and the interest rate is set by the computer. Miscellaneous income includes such items as cash transfers to the capital or current account of the department and income from the sale of land (capital account only).

The Highway Department spends money on road maintenance, bond payments, miscellaneous, construction and land purchase.

The Highway Department must purchase business goods (BG) and business services (BS) for the maintenance and/or renovation of its roads. BG and BS are purchased by the Highway Department at fixed costs from the Outside System. Bond payments include payments on interest and principal of outstanding capital and current bonds floated by the department. Miscellaneous expenditures involve cash transfers from the capital or current accounts of the department to an economic, social, or governmental decision-maker, or from one account to another account.

Each outstanding bond is listed on the bond table, one row per bond. The first item is the type of bond, capital or current. A capital bond has a term of 25 years; a current bond has a term of 2 years. The original principal, remaining term, interest rate, and annual payment are given. The remaining term is the number of rounds after the current round in which the department must make the annual payment. The annual payment is calculated by the computer to pay off the bond in equal installments each year, and the payment is made automatically by the computer from the department's current account.

Below the outstanding bond table is a table which shows the maintenance level, number of segments, and average depreciation of each road type. The Highway Department specified a road maintenance level by road type, not for each individual road segment.

The next table shows the location of road segments at each value ratio (depreciated value before maintenance). Below a road's coordinates is its congestion, the amount which the road is used in peak-hour transportation in excess of its effective capacity. If a road showed a congestion of 30, it would have 30% more use it could effectively handle.

The detail on terminals shows the location, level, design capacity (in terminal units), and terminal units used there.

The location and amount of land (in percent of a parcel) is shown for all undeveloped land owned by the department.

Last, a table shows the locations of roads for which Federal-State aid has been granted but which have yet to be constructed. The road type for which the aid has been approved is also shown.

Highway Department Construction Table

This output shows the site location, type of construction (road or terminal), and old and new level of development of all construction or demolition decisions input by the department and accepted by the computer during the previous round.

Bus and Rail Company Reports

Although the Bus and Rapid Rail Companies are separate quasi-private departments, they will be treated in the same section due to the similarities between the two. Neither is limited to a single jurisdiction; both have interjurisdictional authority.

The Bus Company and Rapid Rail Company provide additional modes of transportation, (besides automobile) to the population units who live and work in the simulated area. Population units take bus or rail to work only; they do not use either mode of transportation for shopping.

The Bus and Rapid Rail Companies own rolling stock with three possible levels of service (1,2, and 3). Level of service indicates the actual number of buses or railroad cars which may serve a particular route.

The number of passengers (capacity that can be effectively served by a rail or bus route) is determined by its level of service. The design capacity of a bus or rail route is not necessarily its effective capacity. Effective capacity is determined by multiplying the value ratio of equipment divided by 100 times the design capacity. Effective capacity can be further reduced by employment. If the Bus or Rapid Rail Company receives only 75% of the employees which it requested, the actual effective capacity of that route is 75% of what it would be if the entire employment needs had been met.

It must be noted, however, that effective capacity does not refer to the number of people who actually use a bus or rail. A bus or rail route may serve fewer or more people than its effective capacity. For example, the bus service with an effective capacity of 5,000 may actually be used by 6,000 people. In such a case the computer has decided that for these people, despite the overcrowding, it is still cheaper in terms of time and money to take a bus rather than another mode of transportation.

The Bus and Rapid Rail Companies do not buy individual pieces of rolling stock. Rather, they purchase units of equipment for each mile of service. Forty units of equipment are required to operate a bus (level of service = 1) for one segment and 80 units of equipment are required to operate a rail (level of service =1) for one mile. Equipment is purchased from the Outside System.

Bus and rail equipment which is used depreciates at an average rate each round. Goods and services for maintenance are automatically purchased from the Outside System (i.e., the computer) at fixed prices.

The Bus and Rail Companies employ workers from middle income population units (PM) only. They obtain their workers through the usual employment process handled by the computer. One PM (160 workers) supplies 1,000 units of labor and 50 units of labor are required to operate a bus (level of service = 1) or rail (level of service = 1) for one mile. One PM of workers therefore serves 20 miles of a BUS1 or RAIL1.

Passengers are assigned to travel to work by bus and/or rail by the computer. The basis upon which a population unit may or may not be assigned to bus or rail transportation is the dollar value of their time. This value is assigned by social decision-makers.

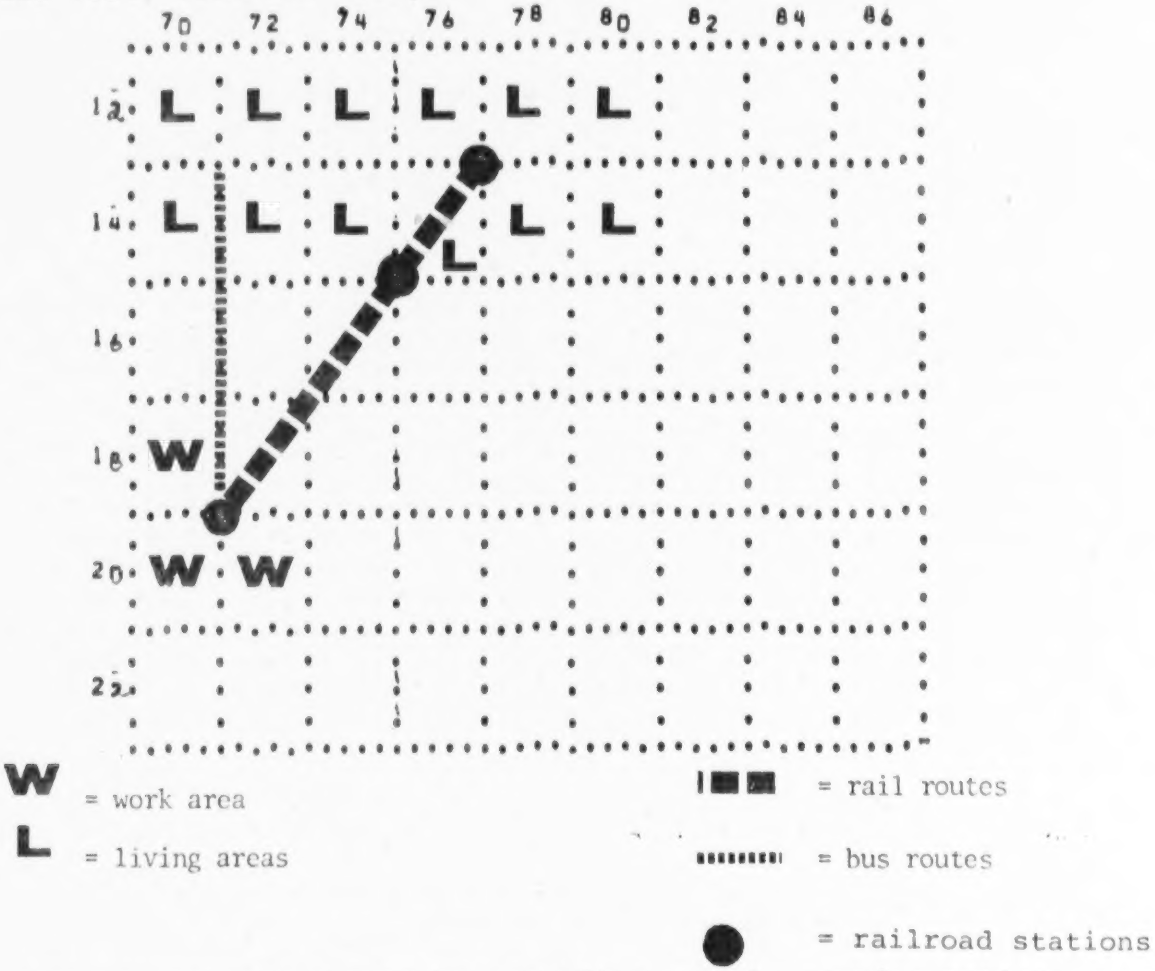
Those population units with the lowest dollar value of time will take the cheapest but probably the longest route of transportation to work. Those population units with a high dollar value of time will take a more expensive but quicker mode of transportation to work.

The following example will demonstrate how the computer considers the dollar value of time. Let us say the transportation costs of a population unit are $150 per year to get to work by bus and $320 to get to work by auto. It also requires an extra 4 time units to travel by bus instead of auto. If the dollar value of time for that population unit was set at $40, it would cost them $150 plus 4 units times $40 (dollar value) or $310 to get to work by bus. To take auto, it costs $320 (no extra time units consumed). Therefore, the computer would assign the population the bus mode to travel to work (i.e., $310 < $320).

In the same case, suppose the dollar value of time was set to $50. Then, the total bus cost would be $150 plus 4 time units times $50 (dollar value) or $350. Auto would cost only $320. Therefore, the computer would assign these population units the auto mode to work (i.e., $320 < $350).

Once a P1 takes bus or rail on the trip to work, it can no longer consider auto to be a modal option during that trip.

Buses travel along roads and trains go along tracks. The Bus Company must therefore specify routes only on existing highways, while the Rail Department can have routes wherever they build tracks, including on the diagonal across parcels and either overground or underground. Routes must begin and end at intersections. Further, although bus and rail transport workers to and from their place of employment, the direction of the route is specified in order to meet residence to work demands. For example, assume that people live in the parcels above the line 15 and that most employment locations are at parcels 7018, 7020 and 7220.



The routes that should be specified are the morning routes that bring people to work. In this instance they are 7113 to 7119 (for bus) and 7713 to 7119 (for rail). A bus stops at every intersection but a rail will stop only where there are stations and there can only be stations at intersections. In the example above therefore, the rail has three stops: 7713, 7515, and 7119. In planning routes decision-makers for bus and rail will often discover that a key element involves the proximity of stops to parcels where the greatest number of people work and/or live.

Although buses do not require land (they operate on highways), surface rail tracks require land (on either side) per mile. A diagonal track requires land from each parcel which it crosses. All land must be purchased by the company prior to the construction of tracks. Underground rail tracks not require land.

Financial Report

Like the Utility Department, the Bus and Rapid Rail Companies are quasi-private departments and therefore do not receive direct appropriations from the Chairman. Both companies, however, can receive income from any of the following sources:

1. Subsidies. These are public subsidies granted by the Chairman to the current or capital accounts of either company.

2. Bonds. Current bonds are automatically floated by the computer if the current expenditures of either company exceed current revenues. Current bonds have a duration of two years and the interest rate is set by the computer. Capital bonds may be floated for either company by the Chairman subject to a referendum by the social sector. Capital bonds have a duration of 25 years and the interest rate is determined by the computer.

3. Fares. The primary source of income for the Bus Company and Rail Company is the fares which they charge to passengers who use their service. Fares are deducted by the computer from the accounts of population units represented by social decision-makers on the basis of 250 trips to work and 250 trips from work each year (round). The fare charged by the company is for a single worker-trip; the yearly amount is calculated based on two trips per day, five days per week fifty weeks per year (i.e., single trip fare times 500).

4. Miscellaneous. These revenues include such items as cash transfers to the capital or current accounts of either company and income from the sale of land (capital account of Rail Company only).

Figure 8.17a

```
DARTMOUTH  ROUND SEVEN

     ...........................................................................................................
      BLUECITY
                          BUS COMPANY REPORT
     ..........................................................................................ROUND  7.........


FINANCIAL  REPORT
-------------------------

                 CAPITAL                                             CURRENT
                 -------                                             -------

     PREVIOUS BALANCE          $     200000.           PREVIOUS BALANCE          $   2041400.

     REVENUES                                          REVENUES
          SUBSIDIES            $          0.                SUBSIDIES            $          0.
          NEW BONDING                     0.                NEW BONDING                650000.
                                                            FARES                     2217800.
          MISCELLANEOUS                   0.                MISCELLANEOUS                   0.
     TOTAL REVENUE             $          0.           TOTAL REVENUE             $   2867800.

     EXPENDITURES                                      EXPENDITURES
          VEHICLE PURCHASE     $          0.                VEHICLE MAINTENANCE  $    714000.
          MISCELLANEOUS                   0.                MISCELLANEOUS                   0.
                                                            SALARIES                  3840000.
     TOTAL EXPENDITURES        $          0.                BOND PAYMENTS              350000.
                                                       TOTAL EXPENDITURES        $   4704000.


     NEW BALANCE               $     200000.           NEW BALANCE               $      5200.

                      OUTSTANDING BONDS
                      -----------------

   TYPE          ORIGINAL     REMAINING    INTEREST       ANNUAL
                 PRINCIPAL       TERM        RATE         PAYMENT
   ----          ---------    ---------    --------       -------

   CAPITAL        5000000.      17            4.9          350000.
   CURRENT         650000.       2            3.2          340000.
```

Expenditures

The Bus and the Rail Companies spend money on the following items:

1. Vehicle Maintenance. This includes the cost of maintenance and renovation costs of vehicles owned by the companies. It involves purchases of goods and services at fixed prices from the Outside System (i.e., the computer).

2. Salaries. Since both companies hire middle income (PM) workers, they must offer competitive salaries.

3. Bond Payments. These include payments on interest and principal of any outstanding capital or current bonds floated by either company.

4. Miscellaneous. These expenditures include cash transfers from the capital or current accounts of the company to an economic or social or governmental decision-maker, or from one account to another account.

5. Vehicle Purchase. This is a capital expenditure for the purchase of rolling stock. One unit of equipment (either bus or rail) has a fixed cost of $10,000. If any stock is sold, this item will subtract the selling price of stock and may indicate a negative number which will be credited to the capital account of the company. The selling price of a unit of equipment is defined as: .50 times value ratio of equipment/100 times the original purchase cost of a unit of equipment.

6. Station Construction. (Rail Company only). This includes expenditures for building stations.

7. Track Construction. (Rail Company only). This includes expenditures for the construction of rail tracks. The cost of diagonal tracks is a function of the hypotenuse of the triangle formed by the rail segment. This relationship is explained below:

Distance for Diagonal Rapid Rail Segments

Horizontal Distance Between Stations

		1	2	3	4	5
Vertical distance between stations	1	1.414	2.236	3.162	4.123	5.090
	2	2.236	2.828	3.606	4.472	5.385
	3	3.162	3.606	4.243	5.000	5.831
	4	4.123	4.472	5.000	5.657	6.403
	5	5.099	5.385	5.831	6.403	7.071

8. Land Purchase. (Rail Company only). This item includes expenditures for land purchased from the governmental or economic sectors or from the Outside System (i.e., the computer).

Employment

As the Bus and Rail Companies hire employees (PM's) in groups of 160 workers, it is in the companies' interest to keep the total combination of service level and route lengths such that "Personnel Required" is equal to or slightly below a multiple of 160. For example, if 328 personnel are required, three PM's would be requested and paid for although only slightly more than 2 PM's would be utilized. Personnel requirements can be calculated using route miles and level of service.

Rolling Stock

Units Owned is the total number of equipment units owned by the company; purchase or sales of equipment are shown here.

Units in Use is equal to the units required up to a maximum of Units Owned; Units in Use is the number of equipment units which undergo depreciation.

Serviceable Units is Units Owned times the Average Value Ratio/100.

One of the considerations entering into the passenger capacity of a route is the "effective" number of units/mile operating on that route (employment and level of service are the other considerations). Each mile of level one route has a requirement of 40 equipment units for full capacity. The total requirement for the system is summed under Units Required. The actual number of units used is the lesser of Units in Use or Serviceable Units. For example, if the units required is 400 and there are only 200 serviceable units, then the passenger capacity is half of the desired capacity of the system.

Passengers

The number under Total Passengers includes transfers from one route to another which is done at no cost. Therefore, they are not all full paying passengers on that route. Passengers who transfer between modes pay costs for each mode. That is, a worker who drove to a bus station, took a bus to a rail station, and took the rail to his place of employment would pay an auto cost and separate fares to the Bus and Rail Companies.

In order to economically carry passengers, Bus and Rail routes must take P1's from where they live (or from where they can economically drive to where they work). Thus, it is important both that the routes have stops (or stations) in many residential locations (and in higher residential density locations) and that the routes provide access to a number of work locations. It would be very uneconomical to have a long winding route through low density residences terminating near only one or two employment locations. (Typical cost/mile and break-even fares are noted in the Master Tables.) As mentioned in the Players' Manual, the routes are directional and are specified to carry workers from residences to their employment location; if a route is specified A⟶B⟶C⟶D, the route would not carry passengers from C to B. A new route C⟶B would have to be specified.

Routes

This portion of the output indicates by route where the bus or rail stops, how many passengers got off at that stop, how many got on, and how many passengers are riding between stops. This information indicates what portions of a route are underutilized and which are overcrowded and thus should affect decisions involving extending, deleting, or upgrading a particular route. The figure for Total Passengers under the transit summary is the sum of all passengers riding the given route, not their distribution; i.e., a route (level 1) may have 9,000 total passengers, but yet be distributed in such a manner that no segment of the route is overcrowded. Data on which segments are overcrowded would come from the Routes output. If a route is highly overcrowded in one round, the computer will probably assign a much lower ridership the following round.

Additional information for each P1 on where they live, where they work, and mode, route and cost of transportation is given in the Employment Detail.

Figure 8.17a

```
ROUTE NUMBER     STOPS


-------------    -----
    101            8531 -->-->-->--  8731 -->-->-->--  8931 -->-->-->--  9131 -->-->-->--  9331 -->-->-->
                   0 1360  1360  1080     0   280      0 2840  3120   920   160  2360   160   760  2960

                 --  9531
                 2960     0     0
    102            8731 -->-->-->--  8729 -->-->-->--  8727 -->-->-->--  8927 -->-->-->--  9127 -->-->-->
                   0  1800  1800     0  3240  5040     0   360  5400     0  1720  7120  2000   320  5440

                 --  9327 -->-->-->--  9527 -->-->-->--  9727 -->-->-->--  9927 -->-->-->-- 10127 -->-->-->
                 1680     0  3760   600   200  3360  3360     0     0     0     0     0     0     0     0

                 -- 10327 -->-->-->-- 10527 -->-->-->-- 10727 -->-->-->-- 10927
                   0     0     0     0     0     0     0     0     0     0     0     0
    104            9137 -->-->-->--  9337 -->-->-->--  9537 -->-->-->--  9535 -->-->-->--  9533 -->-->-->
                   0     0     0     0   120   120     0   120   240     0     0   240   120  1920  2040

                 --  9531
                 2040     0     0
    105            9531 -->-->-->--  9731 -->-->-->--  9931 -->-->-->-- 10131 -->-->-->-- 10331 -->-->-->
                   0  4120  4120  1440     0  2680     0     0  2680     0     0  2680     0   680  3360

                 -- 10531 -->-->-->-- 10731 -->-->-->-- 10931 -->-->-->-- 10929 -->-->-->-- 10927 -->-->-->
                  2720     0   640     0     0   640   640     0     0     0     0     0     0     0     0

                 -- 10727 -->-->-->-- 10527 -->-->-->-- 10327 -->-->-->-- 10127 -->-->-->-- 10125 -->-->-->
                   0     0     0     0     0     0     0     0     0     0     0     0     0     0     0

                 -- 10123 -->-->-->--  9923 -->-->-->--  9723 -->-->-->--  9523 -->-->-->--  9521
                   0     0     0     0     0     0     0  1200  1200     0   800  2000  2000     0     0
    106           10127 -->-->-->--  9927 -->-->-->--  9727 -->-->-->--  9527 -->-->-->--  9525 -->-->-->
                   0   880   880   480  1120  1520   960     0   560   560     0     0     0     0     0

                 --  9523 -->-->-->--  9521
                   0     0     0     0     0     0


LEGEND:   -- SSSSS*-->-->-->        SSSSS   IS INTERSECTION OF STOP,              *    IF LAST STOP IN ZONE
          FFFFF NNNNN PPPPP         FFFFF   IS NUMBER OF PEOPLE GETTING OFF,    NNNNN  IS NUMBER OF PEOPLE GETTING ON
                                    PPPPP   IS NUMBER OF PASSENGERS ON VEHICLE BETWEEN STOPS
```

Sequence of Computer Print-Out

Although sections of the computer output can be distributed in any order and in any combination to players, it is printed in a fixed order with which the director should become familiar. The overall order of output is:

1. Migration
2. Water System
3. Employment
4. Commercial Allocation
5. Social Sector
6. Economic Sector
7. Social and Economic Summaries
8. Government Detail
9. Summary Statistics
10. Maps

Within each of these major output sections there are several subsections. An additional section of print-out results from the processing of decisions on a data base. That print-out, called EDIT, has no fixed sequence within it; the order of decision input is the order in which EDIT processes and lists player and director decisions. The EDIT print-out is separate from the print-outs listed above. These print-outs reflect the simulated region's status in response to the previous year's data base and any changes made to it through EDIT.

Each subsection of output has its own title, but on every subsection the heading for the data base and the round number are printed. A list of the titles of print-out sections in the order in which they are printed and a description of each are given below and are summarized on the next page.

Print-Out Section	Description
1. Migration	
Environmental Indexes	For each class which can live on each residence parcel, this shows the value of each component of the environmental index based on last round's pollution index, MS use index and school use index and this round's residence quality, rent, tax rates, and welfare rates.

RIVER BASIN MODEL OUTPUT

1. Migration
   1.1 Environmental Indexes
   1.2 Personal Indexes
   1.3 Dissatisfaction Cutoffs
   1.4 Migration Detail
   1.5 Migration Statistics
   1.6 Migration Summary

2. Water System
   2.1 Water User Effluent Content
   2.2 River Quality During Surface Water Process
   2.3 Water User Costs and Consumption
   2.4 Coliform and Pollution Index Values

3. Employment
   3.1 Employment Selection Information for PL Class
   3.2 Employment Selection Information for PM Class
   3.3 Employment Selection Information for PH Class
   3.4 Part-Time Work Allocation for PH Class
   3.5 Part-Time Work Allocation for PM Class
   3.6 Part-Time Work Allocation for PL Class
   3.7 Employment Summary

4. Commercial Allocation
   4.1 Personal Goods Allocation Summary
   4.2 Personal Services Allocation Summary
   4.3 Business Goods Allocation Summary
   4.4 Business Services Allocation Summary
   4.5 Government Contracts
   4.6 Terminal Demand and Supply Table
   4.7 Terminal Allocation Map

5. Social Sector
   5.1 Dollar Value of Time
   5.2 Social Decision-Maker Output
   5.3 Social Boycotts

6. Economic Sector
   6.1 Farm Output
   6.2 Residence Output
   6.3 Basic Industry Output
   6.4 Commercial Output
   6.5 Economic Boycott Status
   6.6 New Construction Table
   6.7 Land Summary
   6.8 Loan Statement
   6.9 Financial Summary

7. Social and Economic Summaries
   7.1 Number of Levels of Economic Activity Controlled by Teams
   7.2 Employment Centers
   7.3 Economic Control Summary for Teams
   7.4 Social Control Summary for Teams
   7.5 Social Control Summary Totals
   7.6 Economic Graphs for Teams
   7.7 Social Graphs for Teams

8. Government Detail
   8.1 Assessment Report
   8.2 Water Department Reports
   8.3 Sampling Station Report: Point Source Quality
   8.4 Sampling Station Report: Ambient Quality
   8.5 Utility Department Report
   8.6 Utility Department Finances
   8.7 Municipal Services Department Report
   8.8 Municipal Services Department Finances
   8.9 Municipal Services Department Construction Table
   8.10 Planning and Zoning Department Report
   8.11 School Department Report
   8.12 School Department Finances
   8.13 School Department Construction Table
   8.14 Highway Department Finances
   8.15 Highway Department Construction Table
   8.16 Rail Company Report
   8.17 Bus Company Report
   8.18 Chairman Department Finances
   8.19 Tax Summary
   8.20 Financial Summary

9. Summary Statistics
   9.1 Demographic and Economic Statistics

10. Maps
   10.1 Personal Goods Allocation Map
   10.2 Personal Services Allocation Map
   10.3 Business Commercial Allocation Map
   10.4 Municipal Service Map
   10.5 School Map
   10.6 Utility Map
   10.7 Water Usage Map
   10.8 Water Quality Map
   10.9 Municipal Treatment
   10.10 Municipal Intake and Outflow Point Map
   10.11 Surface Water Map
   10.12 Farm Runoff Map
   10.13 River Basin Flood Plain Map
   10.14 Farm Map
   10.15 Farm Assessed and Market Value Map
   10.16 Market Value Map
   10.17 Assessed Value Map
   10.18 Economic Status Map
   10.19 Highway Map
   10.20 Planning and Zoning Map
   10.21 Parkland Usage Map
   10.22 Socio-Economic Distribution Map
   10.23 Demographic Map
   10.24 Social Decision-Maker Map
   10.25 Topographical Restriction Map
   10.26 Government Status Map

FILMED FROM BEST AVAILABLE COPY

Print-Out Section	Description
Personal Indexes	For each class living on each residence parcel, this shows the value of each component of the personal index based on last round's time allocation, residential crowding, MS use index, and coliform bacteria index.
Migration Detail	For each residence parcel and for each class which lived on the parcel immediately before or after the migration program ran, this shows the number of Pl's in the class now residing on the parcel and of those who moved, why they moved and where they came from and went to.
Migration Statistics	Number of in-migrants, out-migrants, internal migrants, and natural population growth by jurisdiction and class.
Migration Summary	The number of Pl's who moved between or within jurisdictions by class, by jurisdiction and by reason for moving.

2. Water System

Water User Effluent Content	For each economic activity and municipal water system, the volume of effluent dumped into the surface water and the amount of each pollutant in the effluent after the effluent has received any treatment.
River Quality During Surface Water Process	For each of the five stages in the surface water process and for the surface water on each parcel through which a river flows, this shows the water quality rating, the volume of water, and the amount of each pollutant present.

Print-Out Section	Description
Water User Costs and Consumption	This shows for each economic activity the amount of water which it required, the amount which it obtained from its normal source and the cost which it paid to purchase water, to treat its intake water, to recycle water and to treat its effluent.
Coliform and Pollution Index Values	Map showing, for each parcel containing surface water, the coliform count and the water quality rating. The pollution indexes for such parcels and for parcels bordering parcels containing surface water are also shown.
3. Employment	
Employment Selection Information for Low-Income Class	Tabular output showing the place of residence of all Pl's, their employers, the number of Pl's not employed and employed by each employer, the salary of each employer, the time units consumed in transportation to work, the cost of using an auto to go to work, the costs using a bus and/or rail to go to work, and the route used to travel to work whether by auto or public transit.
Employment Selection Information for Middle Income Class	Tabular output showing the place of residence of all Pl's, their employers, the number of Pl's not employed and employed by each employer, the salary of each employer, the time units consumed in transportation to work, the cost of using an auto to go to work, the costs using a bus and/or rail to go to work, and the routes used to travel to work whether by auto or public transit.

Print-Out Section	Description
Employment Selection Information For High Income Class	Tabular output showing the place of residence of all Pl's, their employers, the number of Pl's not employed and employed by each employer, the salary of each employer, the time units consumed in transportation to work, the cost of using an auto to go to work, the costs using a bus and/or rail to go to work, and the routes used to travel to work whether by auto or public transit.
Part-Time Work Allocation For High Income Class	Tabular list of residence location of part-time workers, their employers, the number of part-time units spent working, and the yearly salary rate.
Part-Time Work Allocation for Middle Income Class	Tabular list of residence location of part-time workers, their employers, the number of part-time time units spent working and the yearly salary rate.
Part-Time Work Allocation for Low Income Class	Tabular list of residence location of part-time workers, their employers, the number of part-time time units spent working and the yearly salary rate.
Employment Summary	Information by class and total for the number of Pl's employed at their design level or at lower levels, the number unemployed, the total number of Pl's, the part-time units worked, and the number of jobs full time that were not filled by the local labor force.
4. Commercial Allocation	
Personal Goods Allocation Summary	Tabular output showing the identification number assigned to each PG establishment, its

Print-Out Section	Description
	location, owner, level, effective capacity, actual capacity used, price, and gross sales. For each customer it shows the store to which it is assigned, the customer location and type or class, the customer's owner, the consumption units (including those for maintenance and recreation), transportation costs (shadow costs in the case of residences) the purchase cost (total cost in the case of residences), and total cost.
Personal Services Allocation Summary	This is identical in format to the Personal Goods Allocation Summary but gives details regarding personal services.
Business Goods Allocation Summary	For businesses which require business goods, the format is the same as for personal goods. In addition, there is a section called Government Contracts which shows, for each school and MS department, how many consumption units it purchases from each business goods establishment.
Business Services Allocation Summary	This is identical in format to the Business Goods Allocation Summary but gives details regarding business services.
Terminal Allocation Summary	Tabular list of the location, business type (land use), and terminal requirements of each terminal user. Each terminal is assigned an identification number and its location, level, and usage are noted.

Print-Out Section	Description
Terminal Allocation Map	Map showing the code number of the terminal to which each terminal user in the local system is assigned.
5. Social Sector*	
Dollar Value of Time	This table shows, by team and by class, the dollar value of a time unit spent in travel.
Social Decision-Maker Output	By jurisdiction, by social decision-maker, and by class, a table in which each social characteristic is a row and each residence parcel is a column. The characteristics are descriptive and financial.
Social Boycotts	Detail on who is boycotting, what function they are boycotting, and similar details about social boycotts appear on this output.
6. Economic Sector**	
Farm Output	Tabular list, one row per farm, showing the farm code number, farm type, number of parcels comprising the farm, number of percents of parcels comprising the farm, the farm's fertilizer level, normal income, actual income, land taxes, and total net income.

---

*The dollar value of time prints a table for each jurisdiction, although at this time the value is set for a team and class without regard to jurisdiction. The rest of the social detail prints in order of jurisdiction number, within that in alphabetical order, and within that in order of class (low first, high last). Output for any classes which a team does not control in a jurisdiction is not printed. Likewise, a class having no boycotts receives no boycott output.

**The economic output prints by team in alphabetical order. All of a single team's output is printed before the next team's output begins. A team for which a section of output is irrelevant does not receive that section of output. For example, a team with no residences receives no residence output. Likewise, a team which has no loans outstanding as either a debtor or a creditor does not receive a loan summary. All active teams receive financial summaries.

Print-Out Section	Description
Residence Output	Tabular list of descriptive and financial information about each residence parcel which the decision-maker controls.
Business Output	Tabular list of descriptive and financial information about each business which the decision-maker controls. All basic industries are grouped together and precede the group of personal commercial and business commercial.
Construction Industry Output	Tabular list of descriptive and financial information about each construction industry which the decision-maker controls.
Construction Industries' Contract Table	Description of all contracts made by construction industries controlled by the decision-maker.
Economic Boycott Status	Detail on all boycotts in which the decision-maker is either the party boycotting or the party being boycotted.
New Construction Table	Detail on all construction contracts in which the decision-maker is the contractee.
Land Summary	Tabular list of the location of parcels owned by a team, their assessed value, percent that is undeveloped and private, the taxes on undeveloped land, the percent publicly developed and undeveloped, the percent undevelopable because of topographical constraints, the utility capacity available and used.

Print-Out Section	Description
Loan Statement	Tabular list showing borrower, lender, interest rate, years remaining on the loan, the original principal, and the annual payment.
Financial Summary	A cash flow statement showing expenditures and income, a portfolio of conservative and speculative stocks, a balance sheet of assets and liabilities, and the amount which the decision-maker can borrow.
7. Social and Economic Summaries	
Number of Levels of Economic Activity Controlled by Teams	A table listing the number of levels of each economic activity controlled by each team.
Employment Centers	Table showing the locations, number of job openings, number of Pl's hired, and salaries offered by Federal-State Employers; table showing, for each local government employer, the location of its employment center.
Economic Control Summary*	For each non-farm economic activity, this table shows its location, type and operating level of activity, production index (0-100) or occupancy rate (0-120), net income, and rate of return.

---

*This table prints for each economic team in alphabetical order.

Print-Out Section	Description
Social Control Summary*	For each class living on each parcel controlled by a single two-letter social decision-maker, this table shows the residence location, class, gross income per worker, family savings and total dissatisfaction (quality of life index).
Social Control Summary	By jurisdiction and by class, the number of Pl's controlled by each social decision-maker.
Economic Control Summary	This prints two graphs for each economic decision-maker, in alphabetical order. The first is, for up to ten rounds, the average net income from the team's economic activities each round, expressed as a ratio of the first round's net income. The second is a ten-round history of the average rate-of-return of the team's economic activities, expressed as a percent.
Social Control Summary	This prints two graphs for each social decision-maker, in alphabetical order. The first is a ten-round history of the average net income earned by each class which the team has controlled. The second is a ten-round history of the average quality-of-life index of each class which the team has controlled.

---

*This table prints for each social decision-maker in alphabetical order.

Print-Out Section	Description
8. Government Detail*	
Assessment Report	List of assessment ratios, special assessments and other policies set by the Assessor.
Water Department Reports	List of intake and outflow treatment plant locations, levels, types, capacities, operating costs, volume treated, income, intake and outflow point locations, prices charged to municipal water users, pollutant concentration in municipal effluent (for those districts which are sampled).
Sampling Station Report: Point Source Quality	For those economic activities whose effluent is sampled by the local government, this shows the volume of effluent and the concentration of each pollutant after any treatment.
Sampling Station Report: Ambient Quality	For any parcel on which the jurisdiction measures the quality of the surface water leaving the parcel, this output shows the concentration of each pollutant.
Utility Department Report	Tabular list of utility plants, their location, level, units installed from each plant, units served, total operating costs per unit, and income derived from charges. Also listed is the charge per utility unit to customers, undeveloped land and outstanding bonds.

---

*A department's output is printed for all jurisdictions before the next department's output is printed.

Print-Out Section	Description
Utility Department Finances	Summary of all current and capital revenues, expenditures, and new balances.
Municipal Services Department Report	Tabular list of MS locations, maintenance levels, value ratios, effective capacities, loading (units of capacity used), number PL and PM's working, and the MS use indexes. Also shown are the salary levels, contracts to purchase BG and BS, the locations of undeveloped land, and outstanding bonds.
Municipal Services Department Finances	Summary of all current and capital revenues, expenditures, and new balances.
Municipal Services Department Construction Table	For each MS construction or demolition, this shows the location of the construction firm, the MS location, the status of construction, the old and new level of the MS, the contracted price, the maintenance level, and the number of PL's and PM's assigned to work at the MS.
Planning and Zoning Department Report	Total jurisdiction population, total amount of parkland, outstanding bonds, and capital revenues, expenditures, and new balance.
School Department Report	Tabular data on school unit locations, levels, maintenance levels, value ratios, students attending, teachers, student-teacher ratios, and use indexes. Also data on undeveloped land, BG and BS contracts and cost of purchases, adult education summary, and several summary school statistics.
School Department Finances	Summary of all current and capital revenues, expenditures, and new balances.

Print-Out Section	Description
School Department Construction Table	For each school construction or demolition, this shows the location of the construction firm, the school building location, the status of construction, the old and new level of the school, the contracted price, the amount of federal-state aid used, the maintenance level for the school, and the number of PM's and PH's assigned to work at the School.
Highway Department Report	A financial report showing capital and current expenditures and revenues, outstanding bonds, a summary of maintenance levels and expenditures by road type, a summary of road conditions, a terminal status report, a list of undeveloped land, and a status report on available federal-state aid.
Highway Department Construction Table	For each road or terminal construction or demolition, this shows the construction firm, the location of the road or terminal, the status, the old and new level, the contracted price, and the dollar amount of federal-state aid used.
Rail Company Report	A financial report showing capital and current revenues and expenditures, outstanding bonds, employment costs, the amount and condition of rolling stock, the fare structure, passengers and total fares by route, and the number of passengers using each segment of each route.

Print-Out Section	Description
Bus Company Report	A financial report showing capital and current revenues and expenditures, outstanding bonds, employment costs, the amount and condition of rolling stock, the fare structure, passengers and total fares by route, and the number of passengers using each segment of each route.
Chairman Department Finances	This shows the welfare payment per unemployed worker and the financial summaries for municipal services, schools, highways, planning and zoning, utilities, and the chairman's account. Also included are the Chairman's outstanding bonds.
Tax Summary	Tabular list showing by the eight types of local tax bases, the dollar amount of the tax base, the tax rate, and the revenue generated.
Financial Summary	Tabular list, for each department, of current and capital appropriations, federal-state aid, total revenue, total expenditures and final surplus or deficit.

9. Summary Statistics

Demographic and Economic Statistics	Tabular list by jurisdiction of population and its characteristics, land usage, housing, employment, earnings, income from the national economy, outflows to the national system, and national business cycle effects.

	Print-Out Section	Description
10.	Maps	
	Personal Goods Allocation Map	Map showing the locations and code numbers of all personal goods establishments, locations of all PG users, and the code number of the PG to which each PG user is assigned.
	Personal Services Allocation Map	Map showing the locations and code numbers of all personal services establishments, locations of all PS users, and the code number of the PS to which each PS user is assigned.
	Business Commercial Allocation Map	Map showing the locations and code numbers of all business goods and business services establishments, locations of all BG and BS users, and the code numbers of the BG and BS to which each BG and BS user is assigned.
	Municipal Service Map	Map showing the locations of MS's and their districts, the locations of economic activities, the number of MS units drained by each economic activity and MS use indexes.
	School Map	Map showing the locations of schools and their districts, school use indexes, and the number of children on each residence parcel attending public and private schools.
	Utility Map	Map showing the locations of utility plants and their districts, the number of utility units installed on each parcel, and the number of utility units drained on each parcel.

Print-Out Section	Description
Water Usage Map	Map showing the locations of economic activities, the percent recycling at basic industries, and the type and level of basic industries' effluent treatment plants.
Water Quality Map	Map showing the locations of economic activities, the surface water quality on those parcels having surface water, and the pollutant which caused the water quality rating.
Municipal Treatment Plant Map	Map showing locations, types and levels of municipal intake and outflow treatment plants.
Municipal Intake and Outflow Point Map	Map showing locations of municipal intake and outflow points and the utility districts which they serve.
Surface Water Map	Map showing, for each parcel having surface water, the volume of water on the parcel, its rate of flow, and the percent of the surface area of the parcel consumed by water.
Farm Funoff Map	Map showing for each farm its type and where its runoff flows into the surface water.
River Basin Flood Plain Map	Map showing the locations of river basins, the dam priority of each river basin, and the flood susceptibility of each parcel in the river basin.
Farm Map	Map showing the location of each farm, its owner; its code number, the percent of each farm parcel which is in farm use, the type of farm, and its fertilizer level.

Print-Out Section	Description
Farm Assessed and Market Value Map	Map showing, for each farm parcel, its assessed and market value and the percent of the parcel which is in farmland.
Market Value Map	Map showing, for each privately-owned non-farm parcel, the market value of 100% of the land, the market value of the privately-owned buildings, and the total market value of the privately-owned land and buildings.
Assessed Value Map	Map showing, for each privately-owned non-farm parcel, the assessed value of the privately-owned land, the assessed value of the privately-owned buildings, and the total assessed value of the privately-owned land and buildings.
Economic Status Map	Map showing the economic sector owner of each privately-owned non-farm parcel, its zoning, the type and level of economic activity, the level of utilities installed, and, for every parcel, the percent of the parcel which is privately-owned and undeveloped.
Highway Map	Map showing the locations and types of roads and terminals and the locations, types, and levels of non-farm economic activities.
Planning and Zoning Map	Map showing the zoning classification of those parcels which are zoned, the percent of each parcel which is parkland, and the percent of each parcel which is public, institutional land.

Print-Out Section	Description
Parkland Usage Map	Map showing the percent of each parcel which is in parkland or public institutional use, the population served by the park, and the park's use index.
Socio-Economic Distribution Map	Map showing, for each residential parcel, the type and level of housing and the number of Pl's in each class living there.
Demographic Map	Map showing the population (in 100's), percent occupancy, and quality index (QI) for all residential parcels, and the value ratio (VR) for all private non-residential developments.
Social Decision-Maker Map	Map showing, for each class living on a residential parcel, the social decision-maker which controls the class on that parcel.
Topographical Restriction Map	Map showing the percent of each parcel which is undevelopable due to topographical or other restrictions (e.g., mountains or military bases).
Government Status Map	Map showing the locations and levels of schools, municipal services, utility plants, roads, and terminals.

ENVIRONMENTAL PROTECTION AGENCY
Publications Distribution Section
Route 8, Box 116, Hwy. 70, West
Raleigh, North Carolina 27607

Official Business

CLEAN
WATER

POSTAGE AND FEES PAID
ENVIRONMENTAL PROTECTION AGENCY

If your address is incorrect, please change on the above label; tear off; and return to the above address.
If you do not desire to continue receiving this technical report series, CHECK HERE ☐ ; tear off label, and return it to the above address.